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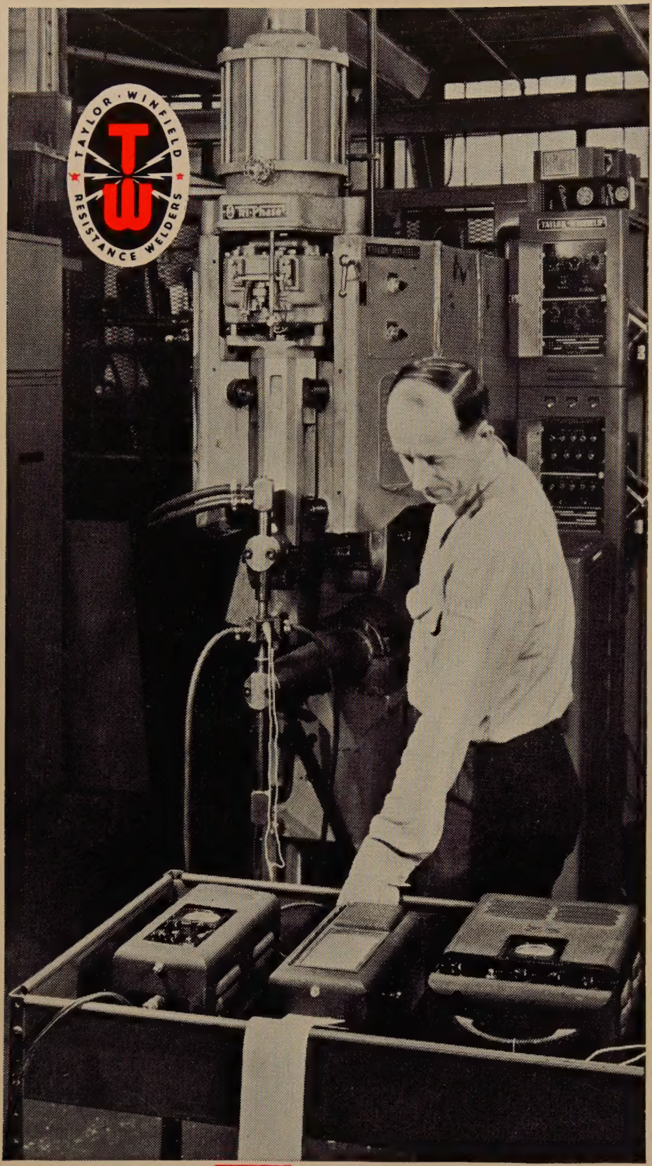

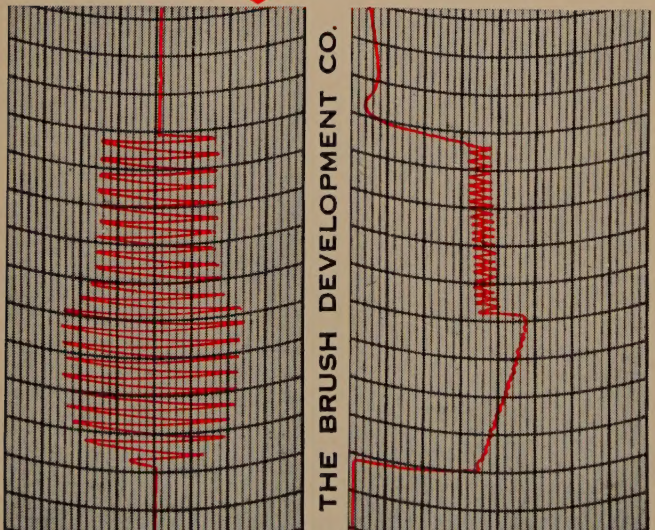

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GENERAL ELECTRIC Review

APRIL, 1951
Vol. 54, No. 4

EVERETT S. LEE
Editor

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Associate Editor

THE COVER

of the site of Hungry Horse Dam in Montana a control carriage on one of the four aerial ways. From here is controlled the placing of ete buckets suspended from the cables. Two of ableways, equipped with adjustable-voltage , also served in the building of Shasta Dam); the third, a-c driven, was used at Ross Dam h.). Because of its superior characteristics, the table-voltage drive is used also for the fourth way. (*See page 25.*)

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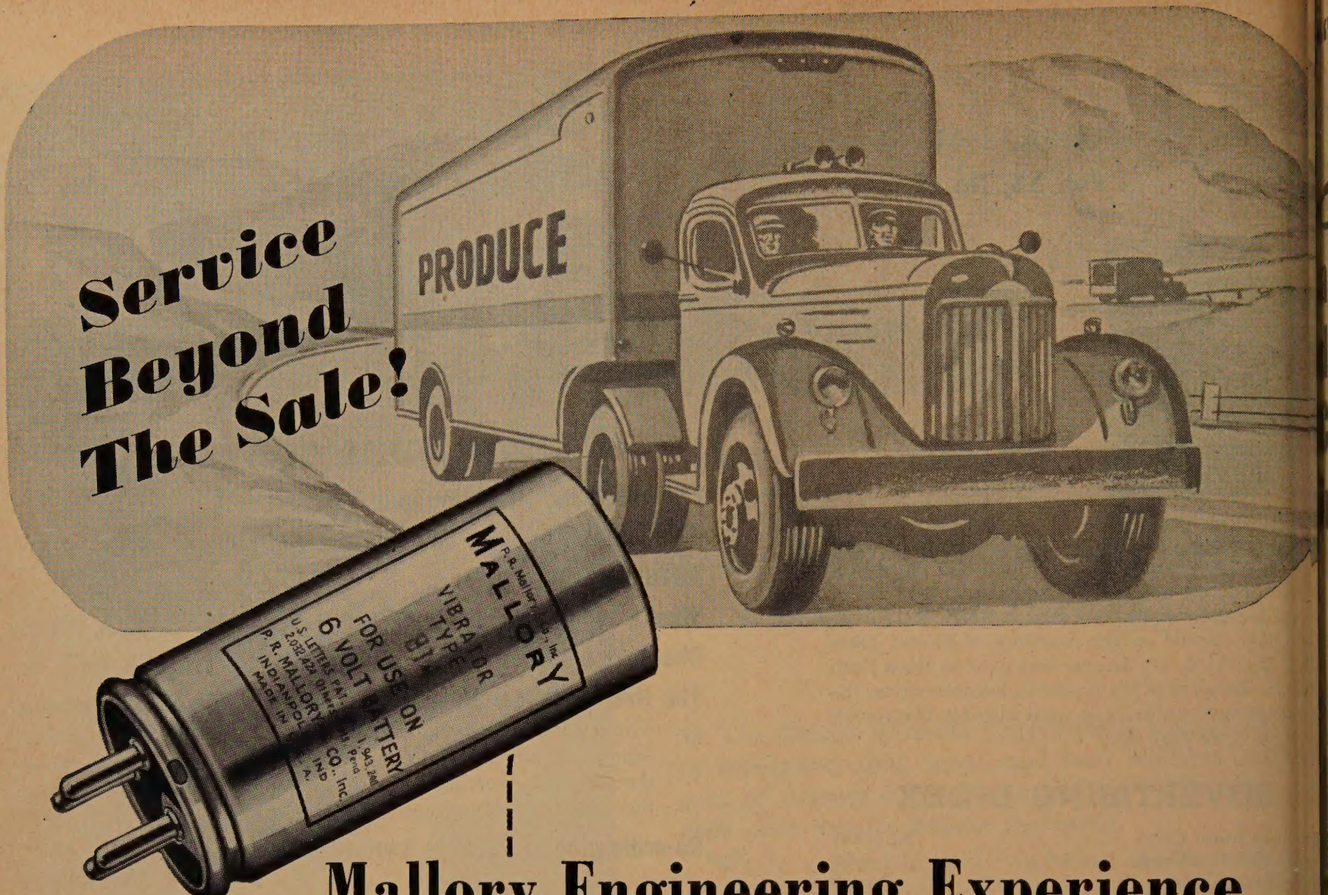

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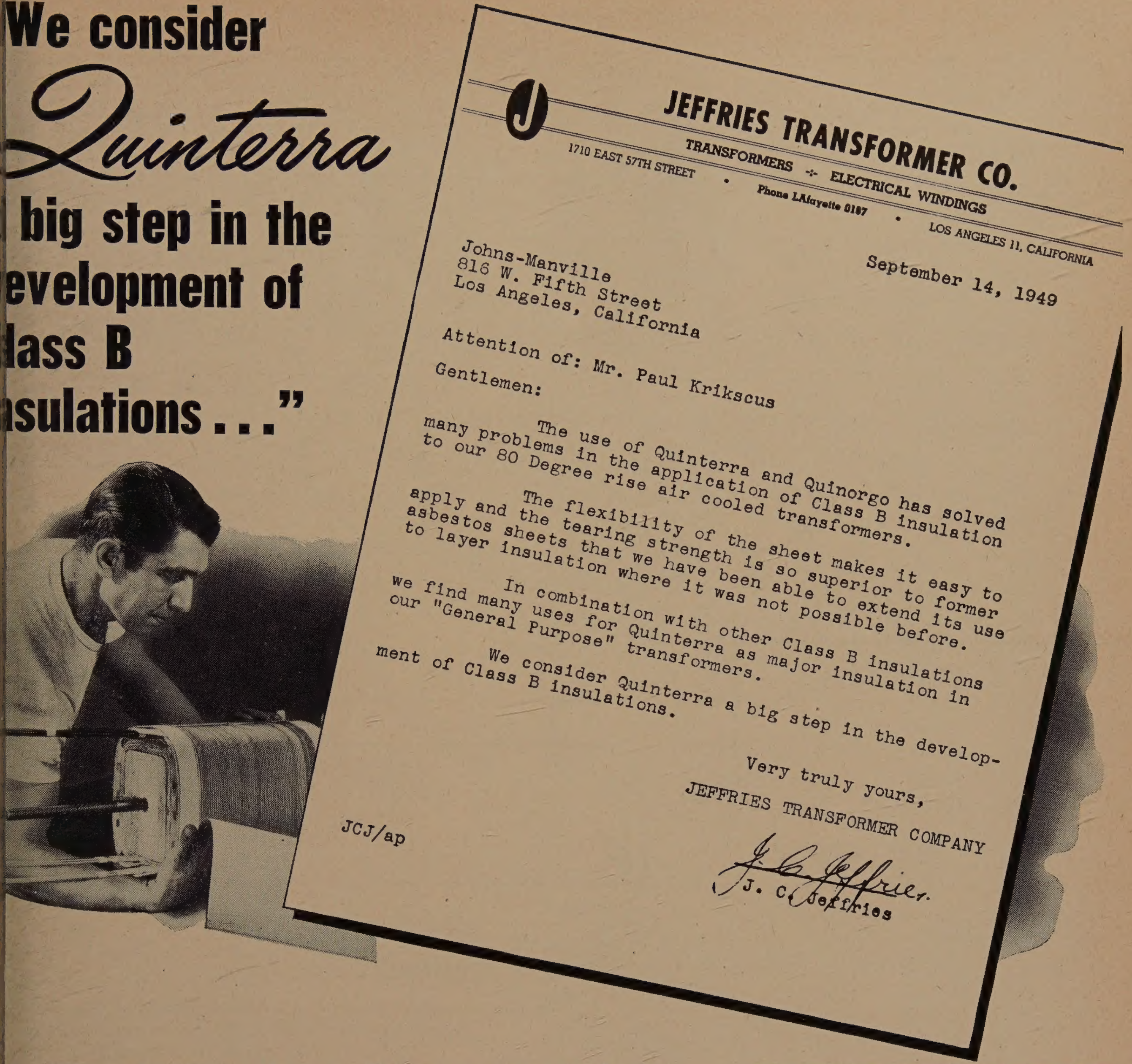

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Group	I		II		III		IV		V		VI		VII		VIII	0
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Period 1	H 1													H 1		He 2
Period 2	Li 3		Be 4			B 5		C 6		N 7		O 8		F 9		Ne 10
Period 3	Na 11		Mg 12			Aℓ 13		Si 14		P 15		S 16		Cℓ 17		A 18
Period 4	K 19	Cu 29	Ca 20	Zn 30	Sc 21	Ga 31	Ti 22	Ge 32	V 23	As 33	Cr 24	Se 34	Mn 25	Br 35	Fe Co Ni 26 27 28	Kr 36
Period 5	Rb 37	Ag 47	Sr 38	Cd 48	Y 39	In 49	Zr 40	Sn 50	Nb 41	Sb 51	Mo 42	Te 52	Tc 43	I 53	Ru Rh Pd 44 45 46	Xe 54
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THE PERIODIC TABLE

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GENERAL ELECTRIC Review

APRIL
1951

AGAIN—TO ENGINEERS EVERYWHERE

UR work to do becomes increasingly clear. Last month I wrote "To Engineers Everywhere," that contribute to maintaining the flow of engineers and tists so essential to our national productivity, by sing the students in their communities that they hard to excel in their courses, and to complete , and to continue on in their engineering and tific education unless they are definitely stopped. p only when stopped" is an excellent motto.

the month past I have had opportunity to visit in olleges and the high schools, and to speak with s as to their experiences; and I find in the high ls the younger boys generally eager to finish their es with excellence, and to go on to college, hopeful their military service will come early enough so that can finish it and return to college still young gh to be able to be graduated under favorable con-ns. The boys 18 to 19 years old, however, need ragement to continue.

r the students in college, the present demand for eers by industry is so great that many are working studying hard to complete their courses that they at least get a start in industry. This attitude is not ral, however; and where it is not, visits by engineers the students should go a long way to make it so, h surely should be our objective.

e can be encouraged that those in the government cies responsible for making the manpower mobili-n rules are most appreciative of the student. The rt of the Scientific Manpower Advisory Committee istinguished men to the National Securities Re-ces Board recommends a program to protect the ent. The program of the Engineering Manpower mission of Engineers Joint Council includes the ent. It is the apparent intent of the government cies that an adequate number of proficient students lowed to continue in their studies as far as possible.

is is the time for every student to work his hardest dvance in school that he may qualify for the ar-ements which will let him serve to the greatest ntage. We in the engineering profession can apply ourselves in our communities to bring this advice to the students.

The headline on a recent report by Arthur Edson from Washington reads: "Hershey's Problem: How to Raise 3,500,000 for Service without Taking Anybody"; reading it, I thought of how we in Engineers Council for Professional Development during World War II pleaded with General Hershey that the engineering student be allowed to stay in school and that the engineer be deferred for critical engineering work, and I well remember how he assured us he understood our position and recognized the needs, but that his responsibility at that time was to get a million men to Europe immediately—for if he didn't there wouldn't be any engineering left here for us to do.

So there must be a balance.

The present prediction for engineering graduates with BS degrees from our engineering schools, even without factoring in the impact of defense mobilization needs, shows clearly that we must do more to interest a larger number of students who have the qualifications to go into engineering. The figures are:

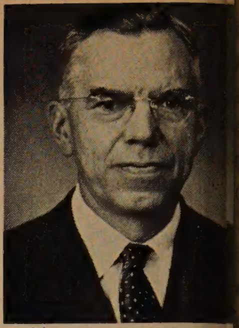
Year	*Predicted Graduates in Engineering; BS Degrees*
1949	47,000
1950	51,000
1951	32,500
1952	21,500
1953	17,000
1954	12,400

With no surplus whatever in these past years, and with needs of at least 30,000 engineering graduates per year, the deficiency we face requires that all who have the qualifications for engineering should be told the facts so that they will be encouraged to prepare themselves to enter the engineering schools.

This is work for the engineers to do in their communities.

Everett S. Lee

WHAT'S JUST AHEAD FOR ENGINEERING STUDENTS



Harry A W

Cyrus Fogg Brackett Lecture delivered at Princeton University, on March 1, 1951

PRINCETON ENGINEERING ASSOCIATION

By HARRY A. WINNE

Vice President

General Electric Company, Schenectady, N. Y.

Dr. Cyrus Fogg Brackett, in whose honor the Cyrus Fogg Brackett Lectureship was established at Princeton University, was born at Parsonfield, Maine, on June 25, 1833. Student, Inventor, Teacher—his was the rare personality of a great physicist and a pioneer in the field of Electrical Engineering in the United States. He had a deep, human interest in the problems of economics, finance, history, and the humanities. His was the belief that the engineer must have understanding of, and sympathy with, these departments of human knowledge and human undertaking.

In 1888, at Princeton, Dr. Brackett planned one of the first formal courses in Electrical Engineering ever given in the United States. It was based upon the belief that the best possible engineering training could only be built upon a broad fundamental discipline in the basic subjects of physics, chemistry, and mathematics, combined with a wide cultural preparation in the humanities.

—EDITOR.

WHEN Dr. Condit invited me to speak to you this evening, he told me the talk would be designated as one of the Cyrus Fogg Brackett lectures. This is indeed a high honor for me but I am quite sure that my simple remarks will not qualify as a "lecture," unless possibly in the following respect: when I was a small boy my father or my mother would frequently find occasion to "lecture" me in regard to my conduct, or perhaps lack of it. There was always included some good advice, usually rather forcefully given. Peculiarly, in most cases, the advice was not new to me and I fully recognized its sound quality, but obviously I needed to have it recalled to my attention periodically. Tonight perhaps you students will think I am "lecturing" to you in the good old-fashioned intra-family way—and perhaps, just perhaps, you need it.

The reason for this last remark is that I am much concerned by what seems to be the too general state of mind of the young men on our college campuses today, as I have observed it, and as it is reported on every hand. It seems almost to border on hysteria, or panic. Often it is an attitude of "what's the use—I'll soon be in the Army." Again, it is a feeling of rebellion or of self-pity because of the uncertainty of the future —and certainly the future is uncertain, and, may I add, *as always*!

As you probably know, General Electric employs about a thousand new technical college graduates each year. Our recruiters are out now visiting the colleges, trying to sign up the 1951 graduates. Everywhere they find pretty much the same condition. The uncertainty about what the future holds is distorting very gravely the viewpoints of the students in all classes; and this, while quite understandable, is, I think, most unfortunate and unnecessary.

We find, for example, that the seniors are not taki advantage of opportunities for job interviews. In t engineering schools recently visited, the senior class totaled about 500 students. From such a number would normally expect at least 200, and probably mo to show up for interviews when our recruiters visit t campuses. Instead of that, only 75 men appeared the first call. We managed to see a lot more by aski faculty members to talk to their classes, impressi upon them the advisability of taking advantage of t opportunity. It seems that most of the men who d not appear felt that they would probably go dire from school to the armed forces, so saw no reason w they should apply for a job.

Well, I suppose this is a perfectly natural attitu under present conditions; but it is not one, in m opinion, that can be justified by thoughtful reasoni In the first place, in most cases, an individual cann be sure that he is destined for immediate milita service. In the second place, and of much greater i portance, the vast majority of those who do go in the service will return to civilian life sooner or later and I think most of them will be surprised at how so that time will come.

That event will probably be a joyful time; but will bring with it new questions, new uncertaintie Then, for each man, will arise the problem of findi his place in our economy, his job. It seems to me ve wise for each senior now to think of that time and do what he can to prepare for it; to take advanta now of every good occasion to meet the representativ of industry as they come to the campuses; to find fro them as much information as he can concerning t opportunities which various organizations offer; to t to determine in what kind of industry, and if possib what company, he would like to cast his lot in uture—which isn't so very far away—and to get ame and his history on the records of this and other companies. Most companies, at least the r ones, do retain for a number of years their ds of college senior interviews.

a man follows such a forward-looking course of n, and then does go into military service, this ration should greatly ease his return to civilian On the other hand, the man who makes no industry acts during his college course will have to start this when he gets out of the armed forces, on his time and at his own expense, and will, I believe, be less likely to find the best opportunity for himself. for the men in the junior and lower classes and among high-school seniors, there are disconcerting nces of a feeling that can be expressed as "Well, be in the Army at the end of the year, so let's a good time and not worry about learning." Again, ctly understandable but very, very shortsighted ing—or perhaps better expressed as lack of think- As I said previously, the average man does not *know* that he will go in the armed forces—and if he does, the time in service will be comparatively for most.

ow I know that for young men a period of two or years ahead does not seem comparatively short. ever, a man in college must think of this time in s of his whole life span, because he is preparing for his entire future, and careless thinking, now, seriously hamper his whole career. Even if a man stined for military service it seems to me there is reason for trying to gain the maximum benefit college now, prior to entering service. When he s out he will be that much more nearly ready for ompetition of civilian life; and that competition t easy.

know that you are plagued by uncertainty and I pathize with you most sincerely. But as you go in life you will find that it is full of uncertainties that the future often appears cloudy, if not down- dark. Usually, however, as one keeps plugging , the clouds open up and the path proves to be o bad as it appeared.

u are not the only people who today are uncertain. ness men are uncertain; uncertain as to how much rial and manpower will be available for production vilian goods; uncertain whether orders for military pment will be placed and engineered in time to fill gaps caused by cutbacks in civilian production; rtain whether selective service, and recall of re- sts, will leave enough engineers to do the jobs that be done. And of course the tendency is to blame overnment—Washington—for all this uncertainty. hen we do that, we should give thought to the mous complexities of the job of planning which our ary and civilian government officials are called to do and ask ourselves what steps we would were we in their places. It seems to me that right ing now is much more difficult than at the start of World War II, for now we don't know if, or when, we may have to fight on a larger scale. So we must be prepared, but as we may have to stay prepared for decades, we must try so to order our preparedness that we do not wreck our civilian economy. This principle holds implications for both military materiel and military manpower. Many of us are inclined to say, "Why doesn't Washington make up its mind and tell us what it wants us to do?" Personally, I feel we should be very grateful that we do have the public argument and debate—even though it consumes valuable time—before deciding what to do. This is one of the strengths of our form of government; and I hope we shall always retain it.

On the subject of manpower, it just happens that Dr. Douglas Brown, Dean of your Princeton faculty, and I, recently served on a Scientific Manpower Advisory Committee, along with ten other representatives of education, industry, and the military services. We were appointed by Mr. Symington, director of the National Security Resources Board, to develop a plan for conserving, continuing, and efficiently utilizing the country's supply of scientific and engineering manpower. I think a résumé of our recommendations may be appropriate to the present subject.

Fundamentally, it seemed to us that since we may have to maintain a sizable military force for a long term of years, a program of universal military training and service is sound. We recommend that the training start upon graduation from high school, but not earlier than age 18 nor later than age 19. Every mentally and physically fit male would be inducted. The training period would be four to six months, and the total training and service term two to two and one-half years. Upon discharge from service, men would remain in a reserve status for a period of years, but would be free to continue their education or to seek employment, as they might choose.

If such a program were adopted, the result would be that after a few years of operation we would have a continuing flow of veterans from service, some going into college, others directly into industry. In effect each man would give from his life, immediately following high school, about two and one-half years to military service, and then would be free to choose his vocation or his educational course in the way which has so long been typical of our American life, and I hope always will be.

There has been much argument pro and con on the question of whether 18 is too young for induction into military service. Personally, I don't believe there is very much difference in maturity between the average 18-year-old and the average 19-year-old, and it seems to me a whole lot better, a whole lot less disrupting, to give the military service between high school and college, rather than to interrupt the college course for it.

Such a program may well mean that our colleges should operate on a year-round basis, so that when a man gets out of service he can complete the normal course for a bachelor's degree in three instead of four years. I believe that veterans, being more mature than normal college freshmen, will benefit more from their college work, will take more interest in it, will be more apt to choose the course for which they are best suited. Certainly after graduation they will more quickly make contributions in industry. At least such is indicated by our experience with veterans in General Electric.

But of course today we do not have such a plan in operation. Our main problem was to devise a program for transition from the present condition to U.M.T.S., without completely interrupting the flow of technical students through our colleges and into industry and the armed services. This we *must not do*. So we recommend that all scientific and technical students entering their senior and junior years in September 1951 be allowed to continue to graduation, so long as they remain in good standing. They have already been pretty well screened by passing through the freshman and sophomore years. We also recommend that, through suitable screening by scholastic, aptitude, and other tests, an appropriate number of those who apply for entrance to the sophomore and freshman classes in the fall of this year and in 1952 be selected and permitted to enter, and to continue their college courses so long as they remain in good standing. Such a number might perhaps be about one-half of what we think of as a normal class. It seems that by 1953 there should be enough young men returning from service, and anxious to enter college, to provide a class of normal size.

Obviously there would also be in many schools Reserve Officer Training Corps units, made up, we suggest, of men selected after completing the four or six months of basic training.

Then we also recommend that men be permitted to apply for entrance in a Reserve Specialist Training Corps, after completing the four or six months training. From those who apply, a number, perhaps 50,000 to 75,000 would be selected, through rigid screening, for deferment during a college course. After graduation, or completion of graduate study, these men would still be liable for approximately two years of assigned military or civilian service. Personally, I hope that the number in this group can be decreased radically in succeeding years, as the flow of men returning from service increases.

A very important part of our proposed program is the setting up of a National Scientific Personnel Board, with suitable regional Boards, which on application by an individual or his employer would take jurisdiction over technical personnel, insofar as their liability for military service is concerned. It would also regulate the number and assignment of Reserve Specialist personnel.

In arriving at our recommendations we tried to give adequate recognition and weight to the various, and often conflicting, points of view. We realize the need for men to fill the armed forces; but we also realize that men without adequate munitions and materiel are almost valueless. We also have full comprehension of the fact that men in civilian industry produce this materiel, and especially that engineers and scientists must be available for research, development, and design of new munitions and other needs of the military forces and of the civilian population. There is increasing evidence t our Department of Defense is quite cognizant of great importance of this last factor.

At the present time, as I am sure you realize if have happened to look at the "help wanted" column the technical magazines and the daily newspap there is a great need for engineers in industry, a sev shortage in fact, particularly in industries which p duce defense equipment and the list of industries producing is growing at an astounding rate. I obse daily demonstration of this in various divisions of General Electric Company. More and more of them being given defense orders, and practically every on those orders requires engineering of a high degree technical competence.

Every year military—as well as civilian—mate becomes more complex technically, requiring m scientific and engineering manhours to develop, bu operate, and service it. I am not aware that any atte has ever been made to estimate the amount of engin ing required on the munitions and materiel needed. the average, for each military man actually in the fi I would venture that the ratio of such a figure World War II to the corresponding figure for World I would be in the hundreds, and should not be surpri if it were in the thousands, and it is still going

And the need is for engineers and scientists who h the most modern training—in other words, young e neers. Most of the recruiting advertisements that I ask for engineers skilled in electronics, or aeronaut or servomechanisms, or other fields which were not all important in World War I.

The Manpower Commission of the Engineers J Council recently asked a number of industries statements as to their situation with respect to e neering manpower. Typical replies were these: "C servation of present technical manpower and a c tinuing supply in the years ahead a major proble "Our engineering programs—seriously and advers affected by current shortage of technical personn "The current shortage of engineering manpower is tailing our present research and development progra "Shortage of engineering manpower is one of greatest concerns at the moment." "Actual experie shows it now requires three times as many engineer design and develop an aircraft power plant as w necessary ten years ago!" And so on!

Industry and our military forces need more and m engineers, but the prospect seems to be that we s have less and less; and this is most unfortunate. fact, the immediate and prospective shortage c stitutes a serious threat to our national strength.

A survey recently made by Dean S. C. Holliste Cornell reveals some disturbing figures. A sim straight-line extension of the prewar demand for e neers indicates a need for at least 20,000 techn graduates annually, and this makes no allowance the requirements of the armed forces. Yet, based on number of engineering freshmen entering in 1950, can expect only 12,000 to 15,000 graduates in 1954.

e in industry are plagued on all sides by material
ages. We are restricted in our use of copper, cobalt,
l, zinc, rubber, aluminum, and many other ma-
s which we need to produce the articles our civilian
lation wants. But our most critical shortage of all
well prove to be that of engineers and scientists.
very fact of the material shortages imposes an
ional engineering load in that it is often necessary
design a product to substitute materials, or to use
f the critical items.

mentioned earlier the tremendous increase in engi-
ng content of today's munitions of war, as com-
l to those in World War I, or even World War II.
k of our airplanes, our tanks, our guided missiles,
tomic bombs, our naval vessels, our radar. And not
are engineers needed to develop, design, and
uce these devices, but the tools and factories which
e them must also be engineered. And then the use
servicing of such complicated equipment calls for
engineers in our military forces.

so, as our civilization continuously becomes more
plex, as our standard of living rises, the need for
neered products, and consequently for the engi-
s to develop and design them, grows.

mention only one important facet of our civiliza-
—transportation—in my lifetime I have witnessed
advent and development of the automobile, the
ane, the diesel-electric and gas-turbine-electric
motive. Let us consider rural transportation. When
s a boy, this was accomplished by horse-drawn
ons, buggies, surreys, buckboards, sleighs, and
ers, terms whose very meaning many of you may
know. A considerable amount of craftsmanship, but
eal engineering as we know it today, was involved in
design and building of a four-wheeled horse-drawn
cle. And no engineering was involved in building
maintaining the dirt roads. This was usually done
eighboring farmers, working out their poll tax with
and scraper, plow and roller. Almost any good
enter could build a wooden bridge over a narrow
m.

ompare the situation then with the amount of engi-
ing which is today involved in our automobiles and
fantastic machinery which manufactures them, in
concrete highways, in our steel bridges, in our
ic signals, in our gasoline producing plants, in our
side service stations, and so on.

ruly, the engineer, in lightening the burden of man's
sical toil, is making more and more jobs for himself.
en wonder what the end situation will be.

suppose you are thinking that I haven't given you
real information on the subject of this talk, the
ediate future of the engineer. I grant you, as I said
er, that it is uncertain; but the future is always
ertain, in one way or another. When you entered
ol here, were you certain you could do the work and
plete the course; were you certain of a job, if and
n you do get through? I think most of you were not.
you have the added possibility that you may go
the armed forces for awhile, but what of it?

I personally feel that many of you, if you will just settle down and work, will have the opportunity to complete your college courses, and to secure jobs in industry. Certainly we in General Electric are trying to hire a lot of this year's graduates—we need them, and we hope we will be able to hold them, to do the essential engineering we have ahead of us. And we are only one company, in only one industry.

In any case, my advice, speaking very bluntly, is: quit worrying, and put your effort into the job immediately ahead of you, which is to get just as much education as you can. It is the same sort of advice which I so often have occasion to give to young men in our organization who come to me, worried about their future, worried because they feel they are not getting ahead as fast as they should. In my experience, the man who devotes his energy to doing the very best he can on his today's job is much more apt to succeed than the one who is unduly concerned about his future, trying to pull strings to get ahead, wondering whether "the other fellow" is getting ahead faster. I certainly do not mean that a man should give no thought to, and do no planning for, his future. But in this, as in everything else, strive for a reasonable balance.

Well, what is the net of all these remarks I have made. Simply this: Your country badly needs young men with engineering or other technical training; most of you young men here tonight have the opportunity to get such training right here at Princeton; I urge you most earnestly to take full advantage of that opportunity, for the good of your country—and I wish I could make the same plea to capable young men in the other good engineering and scientific schools scattered throughout the United States.

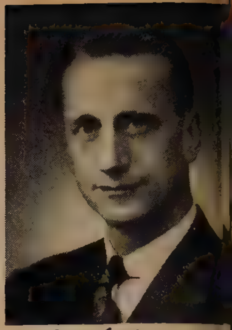
I know that many of you feel you ought to volunteer for active military service—you want to do your duty, you do not want to be slackers. Has the thought occured to you that if you have the ability and the opportunity to pursue your engineering education, you may well contribute more to your country by doing that than by dropping out of college and going into military service? Remember that engineering is a profession, and that a real professional man's whole career is one of service, service in the highest sense.

You may have noted that bills now before Congress on the matter of military service give recognition to the importance of maintaining a flow of men through our scientific, engineering, and medical educational institutions, and into industry, as well as into military forces. In World War II we paid little attention to this most important matter, whereas almost all other countries did implement such a program. Perhaps we were lucky that the war did not last longer, for then the shortage of engineers in our reconversion effort would have been much more acute.

Now we face the possibility of a long, long period of heavily armed preparedness, and we dare not stop the flow of engineers and scientists into our economy, even for a year or two. You are a part of that stream. You can help to keep the stream flowing. I hope you will do your part.

CHECK LIST FOR INDUSTRIAL PLANT CIVIL DEFENSE PLANNING

By C. H. MUIR, JR.
Works Security Agent, Schenectady Works
General Electric Company



C. H. Muir

In the following article, Mr. Muir has made a résumé of the available material on the subject, and has presented it in such a way as to make it easily useful for others who have the responsibility for Industrial Plant Civil Defense Planning. The paper which was the source of this article was presented as part of a Conference on Business, at Union College, Schenectady, New York, on February 27, 1951.

Theme: "What Is Ahead for Business, Industry, and Your Community in This National Emergency?" Emphasis: Civil Defense, Manpower, and National Affairs. Co-Sponsors: Union College, Chambers of Commerce in Albany, Amsterdam, Gloversville, Saratoga Sprin Schenectady, and Troy, New York, in conjunction with the Empire State Association of Commerce and the Un States Chamber of Commerce—EDITOR.

CIVIL DEFENSE is a subject of such broad scope that it must be divided into component parts to permit intelligent consideration. Even in the industrial field, conditions vary so widely that, within existing limitations, it is possible to deal with any particular part of the subject only in very general terms. The objective of this outline is to furnish a number of signposts, all of which will point the way to sound planning for a program and provision for civil defense in an industrial establishment.

Planning for civil defense of industrial plants should take into consideration at least the factors outlined. Provisions which are suitable for one plant or installation will not necessarily meet the needs of another plant since conditions differ between rather wide limits. The plans for any particular plant should provide for the conditions peculiar to that plant and should be co-ordinated with the organization and planning of the city and county civil defense setup.

PANIC CONTROL

There are now available numerous articles and pamphlets dealing with the atom bomb, civil defense, and related subjects such as first aid and fire fighting. Many of these are excellent and serve the purpose for which they were produced. However, in the writer's opinion, too little emphasis has been placed on the greatest single danger involved—panic. The possibility of panic and its results are too well known to require elaboration. Panic, like influenza, is highly contagious. It is usually bred by irrational fear which results from insufficient or incorrect information or training. Moreover, panic can be fostered by false or malicious rumors.

Any adequate disaster plan, whether it cover fire, flood, or the atom bomb, will include the basic steps of panic control. Summed up briefly these are:

(1). Preparation—or provisions made in advance for necessary organization of personnel and equipment
(2). Information—which will dispel sensatio misunderstanding and create an awareness the real dangers
(3). Training—which includes going through prescribed procedure.

If each person has been carefully told and sho what he is expected to do, the likelihood of panic will reduced to a minimum, or even eliminated.

PLANT COMMUNICATION AND WARNING SYSTEM

The plant communication and warning system sho be capable of providing a rapid and dependable mea of transmitting signals to key personnel, and in f all personnel as needed.

INSTRUCTION OF PERSONNEL

All personnel concerned should be advised throu the most effective media on various phases and progr of civil defense. The limitations as well as the ca bilities of the atom bomb should be made clear in or to dispel misunderstanding and the tendency tow "atom bomb hysteria" born of ignorance or distort information. Information can be distributed in t form of pamphlets, bulletins, or a plant publicati Special information should be given covering spec conditions existing in different sections or buildin for example, provisions to cover areas containi flammable or explosive materials or other unus hazards.

Specialized instruction and training should be gi to different groups of key personnel associated w specific duties, for example, air raid wardens, auxili police, rescue or first aid squads, medical personn maintenance and power plant personnel.

SHELTER AREAS

A survey of each building and facility is necess to determine which areas may be used for shelter, under existing conditions, or (2) after necessary re forcement or alterations, and which areas are suita for the construction of shelters.

ERSAL OR EVACUATION

he decisions and policy as to dispersal or evacua-
of personnel will necessarily depend on several
rs such as:

). Distance of plant from probable target area(s)
). Accessibility of shelter areas
). Number and capacity of exit routes
). Effectiveness of traffic control measures
). Regulations (national, state, and local) covering evacuation and traffic.

RGENCY MEDICAL SERVICE

mergency medical service should include organiza-
and training of plant personnel with particular
hasis on treatment and evacuation of casualties.
will involve

). A survey of medical personnel and supplies in the plant
). Organizing, equipping, and training of rescue teams
). Instruction in treatment and evacuation of casualties
). A program of first-aid training, possibly for all personnel
). A system for identification and registration of casualties
). Notification of relatives of casualties.

IAL PLANS, ORGANIZATION, AND EQUIPMENT FOR FIGHTING

oncerning fires, the following is a partial quotation
the publication "The Effects of Atomic
pons:"* ". . . it would appear that relatively few
he numerous fires, which developed almost instan-
ously after the atomic bombing of Japan, out to
ances of 4000 to 5000 feet from ground zero . . .
e due directly to thermal radiation from the bombs.
It is probable that most of the fires originated from
ndary causes, such as upsetting of . . . stoves, . . .
trical short circuits, broken gas lines, and so on
ch were a direct effect of the blast wave. In several
s, fires in industrial plants were started by the over-
ing of furnaces and boilers, and by the collapse of
dings on them.
Another contributory factor to the destruction by
was the failure of the water supply in both Hiro-
a and Nagasaki. The pumping stations were not
ely affected, but serious damage was sustained by
ributing pipes and mains, with a resulting leakage
drop in the available water pressure. Most of the
s above ground were broken by collapsing buildings
by heat from the fires which melted the pipes."
rom the foregoing quotation, it seems clear that
ial provisions for fire fighting should provide for
probable failure, partial or complete, of the plant
er supply system. In addition to other provisions,
fighting personnel or teams should be located
ughout the plant. Particular attention should be
n to areas containing such things as furnaces, ovens, gasoline or oil tanks, combustible gas tanks or lines, and other flammable or explosive materials.

DAMAGE CONTROL

Plans should cover the assignments of maintenance, power plant, and service personnel:

(1). Before an attack, with specific details such as which power circuits, steam, air, and gas lines are to be shut down and which are to be maintained. Instructions should cover actions to be taken upon receipt of "Yellow Alert," "Red Alert," and "All Clear" signals. Provisions should include assembly points for maintenance and service personnel who are off duty or out of the plant at the time of the signal or attack. A survey should be made to determine the need for locating special repair equipment, replacement parts, and wiring or piping diagrams outside the plant.

(2). After an attack, working in conjunction with radiation survey team(s), power plant maintenance and service personnel designated to do so should first survey the plant to determine extent and nature of damage and plan restoration of services on a priority basis.

PROTECTION OF VITAL COMPANY OR PLANT RECORDS

Consideration should be given to the need for protection of company or plant records considered vital to restoration of business after an attack. Such records might include the following: payroll, accounting, personnel, pension, insurance, and corporate records; wiring and piping diagrams for the factory, and engineering drawings and manufacturing and process instructions for products.

Protection can be afforded by (1) maintaining vital portions in fire- and blast-resistant vaults; (2) storing microfilm records at distant locations; (3) storing duplicates of vital portions at distant locations.

IDENTIFICATION OF KEY PERSONNEL

It is probable that restrictions and regulations will be forthcoming covering movement of personnel and vehicles in a target area (or assumed target area). This will mean that persons who have been assigned civil defense duties should be furnished with any identification or credentials needed to permit carrying out their assignments.

KEEPING PLANS CURRENT

Civil defense plans and organization should be reviewed from time to time to keep them up to date. The need for review will be indicated by:

(1). Passage of time, perhaps several months
(2). Significant changes in plant organization, key personnel, buildings, or facilities
(3). Receipt of additional or revised information or regulations from national, state, or local civil defense officials.

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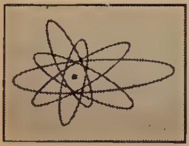
*U.S. Government publication by U.S. Dept. of Defense and U.S. Atomic Energy Commission, available from Superintendent of Documents, Washington (D.C.)—EDITOR.

THE NEW CHEMICAL ELEMENTS

The search for new knowledge of the universe is marked by significant advances in each generation. One of these steps is the discovery and definition of new elementary particles and the consequent extension of the list of chemical elements

Saul Dushma



By Dr. SAUL DUSHMAN
Research Consultant, Research Laboratory
General Electric Company

ALL matter, mineral and organic, is made up of combinations or mixtures of elementary substances known as chemical elements. Before 1937, about 88 such elements had been found. About 30 of these elements occur on the earth, in the free or chemically uncombined state. Examples of such elements are: the gases hydrogen, oxygen, nitrogen, and argon, which occur in the atmosphere; the metals gold, platinum, silver, copper, and mercury; and the nonmetals carbon and sulphur. Each chemical element is made up of infinitesimally small corpuscles, which were originally designated *atoms*, because they were assumed to be indivisible. The atoms of any one element are the same in size, mass, and chemical properties. If we assign to the atom of the lightest element (that is, hydrogen) the atomic weight 1, then the atomic weight of uranium—until 1940 the heaviest known element—is 238. The diameters of atoms of the different elements vary from about one hundred-millionth of an inch to about three times that value.

About fifty years ago, it was discovered that white-hot metals, when negatively charged, emit electrons. These have been shown to be extremely small particles each of which carries a unit charge of negative electricity and has a mass about 2000 times smaller than that of the hydrogen atom. The diameter of the electron is about one hundred-thousandth of that of an atom. Also, at about the same time, the phenomenon of radioactivity was discovered; that is, it was observed that certain high-atomic-weight elements disintegrate spontaneously into elements of lower atomic weight. Thus it was recognized during the first decade of the present century that the *atom is not a simple*, spherically shaped little mass, *without structure*, but must be composed of still more elementary particles, which govern the observed chemical and physical properties of the different chemical elements.

A first approximation to the solution of the problem regarding the structure of the atom was given, in 1911, by the late Sir Ernest Rutherford. As the result of a brilliant series of investigations, he reached the conclusion that the atom consists of a *positively charged nucleus* (or core) surrounded by as many electrons as the number of unit positive charges on the nucleus. This number is known as the *atomic number* of an element, and an element of atomic number X will
referred to in this article as *element X*. This numb
varies in value *from 1 for hydrogen* to *92 for uraniu*
Thus the uranium atom consists of a nucleus havi
92 units of positive electricity and 92 electrons,
volving in orbits about the nucleus. Since the mass
even 92 electrons is about one fiftieth of one perce
of the mass of the uranium atom, it follows that nea
the whole mass of the atom is concentrated in t
nucleus. And yet, since the diameter of the nucleus
only about one hundred-thousandth of that of t
atom, we must conceive of the atom as an extreme
miniature solar-like system in which most of t
volume is just empty space. There is a periodicity
the distribution of the electrons in orbits, whi
corresponds to a periodicity in chemical and physic
properties of the elements when these elements a
arranged in order of increasing atomic number,
shown in the periodic table in the FRONTISPIECE. Th
we find that the elements fall into eight groups, wi
chemically similar elements in each group. This grou
ing is due to the configuration and number of electro
which are outside the nucleus.

Turning now to a consideration of the structure of t
nucleus, it was discovered, in 1934, that besides t
electron, and the *proton*, which is the nucleus of t
hydrogen atom, there also exists, in all the nucl
another elementary particle, the *neutron*. This partic
has *zero charge* and a very slightly higher mass th
that of the proton. Our present view, therefore, bas
on this discovery and a large number of observatio
is that *the nucleus contains both neutrons and protron*
The number of protons is the same as the ato
number (that is, the number of extra-nuclear electron
and the number of neutrons is equal to the differen
between the atomic mass and the number of proto

Since the chemical properties of an element a
governed solely by the atomic number (that is, t
number of protons), it is possible to have two or mo
kinds of atoms which are chemically inseparable, b
which have different atomic masses. This is becau
of differences in the number of neutrons in the nucle
Such atoms are known as *isotopes*. Thus, the nucleus
ordinary hydrogen is designated the proton; but the
is also an isotope of hydrogen of mass 2, the nucle
of which consists of a proton and a neutron. Th
nucleus is designated the *deuteron;* and while it h

This article was presented by Dr. Dushman as a talk at the General Electric *Science Forum* broadcast on December 27, 1950 from Station WGY, Schenectady, N. Y.—EDITOR.

same charge as the proton, it has about twice the s of the proton. A large number of the elements e 2 or more isotopes, and in the case of the heavier lei, these are radioactive; that is, they decay ntaneously with emission of high-speed electrons, amma rays, or α particles. *The latter* are the *nuclei elium atoms* and consist of 2 protons and 2 neutrons. v the very important discovery has been made that possible to *transmute* nuclei of a radioactive ele- t number X into nuclei of an element number $X+1$ $X+2$ by bombardment with protons, deuterons, or um ions. Since protons and deuterons have a nuclear rge of 1 positive unit and helium ions as well as ha particles have a nuclear charge of 2 positive s, these particles may be accelerated to very high *cities* by means of high voltage in much the same nner as electrons are speeded up by high voltage n x-ray tube. The velocities thus acquired by the itively charged particles are of the order of one- h to one-half of the velocity of light. Under these ditions, the particles gain sufficient energy to enable n to *penetrate* and *combine* with the nucleus of a nbarded atom of element number X. The result is atom of element number $X+1$ or element number -2, depending upon whether singly-charged particles doubly-charged particles are used as bombarding jectiles. That is, an atom of the bombarded element mber X) is transmuted into an atom of a totally erent chemical element, of higher atomic number.

t is in this *manner* that the four elements previously sing below uranium, and also elements of higher mic number than uranium, have been synthesized ecent years.

he first of the elements to be synthesized in this nner (in 1937) was number 43. Molybdenum is num- 42, and by bombarding this element in a cyclotron h deuterons, the new element, number 43, was ob- ed. Since it was the first element produced artifi- ly or technically, it was designated *technetium* (Tc). emical tests showed it to be an element chemically ilar to manganese, as had been expected.

n 1938, element number 61 was produced by bom- ding neodymium, element number 60, with deu- ons. It corresponds to a long-sought-for element, erto missing in the series of 15 rare-earth elements ch occur in the periodic arrangement between *ium* (number 56) and *hafnium* (number 72). This ly discovered element has been designated *pro- heum* (Pm).

n 1940, element 85 was produced by bombardment bismuth, which is number 83, with high-speed helium s. The new element was indentified as a member of same chemical group as chlorine, bromine, and ine. Accordingly, it was designated *astatine* (At), nifying "unstable."

rancium (Fr, atomic number 87) was discovered, in 9, as a short-lived radioactive form which occurs in decay of other radioactive elements such as uranium radium. It corresponds, chemically, to the long-sought-for element "eka-cesium," which belongs to the same alkali metal group as cesium.

With the synthesis of these four elements *all the 92 places* in the periodic arrangement of the elements, beginning with hydrogen and ending with uranium, were completed. But in the course of the investigations on the fission of uranium, four new *transuranic* elements, (that is, elements beyond 92) were discovered. The first of these, number 93, was produced in 1940 by irradiating uranium with deuterons, and was designated *neptunium* (Np), by analogy with the planet Neptune, which is beyond Uranus.

Element 94 was produced, later in 1940, by bombarding uranium with α particles. Again, by analogy with Pluto, the outermost of the planets, this new element was designated *plutonium* (Pu). Both neptunium and plutonium are produced in the atomic pile as a result of the emission of neutrons by the isotope of uranium of mass 235.

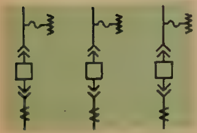
By irradiating plutonium with helium ions, element 96 was synthesized in 1944, and designated *curium* (Cm). In 1945, the element 95 was discovered by a group of investigators engaged on the Plutonium Project, and designated *americium* (Am), by analogy with *europium*, number 63, which is a member of the rare earth series. Theoretically, this new element could be synthesized by bombarding plutonium with deuterons. Finally, early in 1950, it was announced by a group associated with Dr. Seaborg, working at the University of California, in Berkley, that two elements of still higher atomic numbers had been synthesized. *Element 97* was produced by bombarding americium, number 95, with 30- to 35-million-volt energy helium ions. To this element the name *berkelium* (Bk) has been assigned. *Element 98* was synthesized, in the same manner, by bombarding curium (number 96) with high-speed helium ions, and this new transmutation product has been designated *californium* (Cf).

Whether any elements of still higher atomic number will be discovered, is quite problematical, since all the elements beyond uranium are quite unstable—that is, they disintegrate rapidly. The main fact revealed by the syntheses of the new chemical elements is that the atoms of the different elements are not really the elemental particles of nature. Rather, the atoms themselves are constituted of three *still more elementary particles;* namely, *electrons*, *protons*, and *neutrons*. We know, in fact, that in the hottest stars, in which the temperature near the center is about one hundred million degrees centigrade, some of the atoms themselves have been decomposed into these three elementary particles. Of course, other particles have been observed, but whether they are essentially elementary remains to be discovered.

This is certainly not the last word on the whole subject. However, whatever the future may reveal, we believe that we have made one more step forward in acquiring some knowledge of that great universe about us, of which we can be only reverent observers and humble interpreters.

CO-ORDINATION OF PARTS IN SWITCHGEAR ASSEMBLIES

Co-ordination provides assurance that each part is properly selected for its job and, therefore, that the whole assembly will reliably perform as intended. How the designer attains this co-ordination in factory-assembled switchgear



By F. L. MUSSELMAN
Panel and Equipment, Switchgear Divisions
General Electric Company

EVER since the early stages of development of electric-power systems the power circuit breakers have been designed on the basic premises that the breakers must be capable of (a) interrupting the maximum short-circuit current available at the point of application and (b) withstanding the mechanical and thermal effects of this current prior to and during interruption.

The extension of the second of these premises as a basis for the design of other parts of a switchgear assembly has been a somewhat more gradual development. Even though this basis has gained wide acceptance recently, components which would meet the requirements have not always been available for all applications. For example, current transformers of some standard ratings could not always withstand the mechanical and thermal stresses set up by short-circuit currents equal to the interrupting ratings of associated power circuit breakers. Similarly, potential and control-power transformer fuses which could successfully interrupt these heavy short-circuit currents have become available only fairly recently in all standard ratings.

At the present time, however, component devices are available in such ratings that the switchgear manufacturer can produce fully co-ordinated equipments, all elements of which will withstand short-circuit currents up to the interrupting rating of associated circuit breakers.

CO-ORDINATED EQUIPMENTS

As one example of fully co-ordinated equipment, reference will be made in this article to factory-assembled metal-clad switchgear having removable power circuit breakers. These equipments consist basically of a metal-enclosed fully insulated bus, removable power circuit breakers using either air or oil as the interrupting medium, and current and potential transformers—all located in the switchgear. A single-line diagram of such an equipment is shown in FIG. 1, and a side view in FIG. 2. This type of equipment is built in ratings from 2.4 to 13.8 kv and from 50 to 500 mva interrupting rating.

CIRCUIT BREAKERS

Since the circuit breaker is the major and most important component of a switchgear assembly, its rating usually becomes the basis for rating the entire assemb and the various ratings of other components are ther fore co-ordinated with the breaker rating.

The ratings of circuit breakers used in switchge equipment are selected after careful study of the co ditions under which the breakers are to operate,

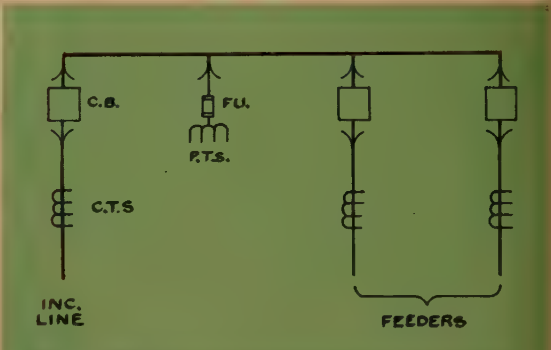


Fig. 1. Single-line diagram of typical metal-clad switchgear equipment

insure that these devices have momentary and inte rupting ratings high enough to withstand the heavie duty which can be imposed on them by the system which they will be connected, and also to be certa that the continuous current and voltage ratings a adequate.

The *momentary* rating of a power circuit breaker expressed in RMS amperes, and is the maximum cu rent which can be passed through the breaker witho causing mechanical damage. That rating of a proper applied breaker is at least equal to the highest value RMS current that the circuit can produce. This ma mum value of current occurs during the first cycle aft the inception of a fault under maximum system-fau conditions. It is made up of the a-c component of sho circuit current (steady-state short-circuit current) a the d-c component (a transient that decays expone tially with time). Theoretically the RMS current in t first half cycle of short-circuit current could be 1. times the RMS value of the steady-state short-circu current. A wave with maximum d-c component, ho ever, requires a half-cycle to reach its crest value; a since this d-c component decays very rapidly duri the half-cycle, a factor of 1.6 (and less for low-volta uits) can be used to express the relation between steady-state and maximum short-circuit currents. he *interrupting* rating of a power circuit breaker is essed in RMS amperes, and is the maximum cur- which the breaker can interrupt without suffering age. That rating of a properly applied breaker is al to, or greater than, the steady-state short-circuit ent that can be developed at the point in the system re the breaker is located.

he *voltage* and *current* ratings of a breaker simply cate the maximum limits of continuous voltage and ent for which the breaker is designed. When the ker is properly applied, these ratings are equal to reater than the system voltage and the maximum inuous load current at the point in the system re the breaker is connected.

RENT TRANSFORMERS

urrent transformers are also given primary con- ration in co-ordinating the components of factory- mbled switchgear. The criteria to be employed in cting the type of these transformers for a particular allation or circuit are: (1) the insulation rating; (2) primary current rating; (3) the accuracy; (4) the hanical rating; and (5) the thermal rating.

ith regard to the *insulation* rating of the trans- ner, the choice is usually that of selecting either or 15 kv, since these are the two standard insula- ratings which apply for switchgear of the type er consideration.

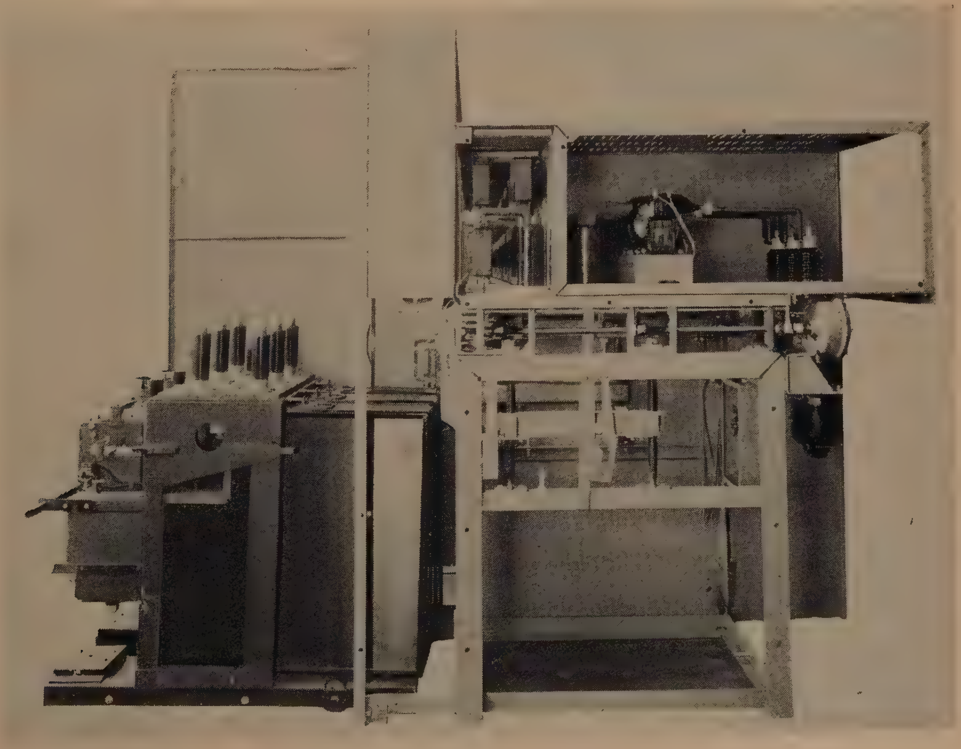
he *primary current* rating is generally selected by ulating the expected current at the point where the sformer is to be installed and then choosing the dard primary rating that will give a good pointer ection on the indicating instrument scale when the uit is operating under full-load conditions.

As to *accuracy*, the American Standards Association has established (under ASA-C57.13) a means of classifying the metering and relaying accuracy of all instrument transformers. It is, therefore, necessary only to refer to these standards to determine the desired accuracy in the special cases where this rating is a prime factor for consideration in system layout.

It should be mentioned at this point that the mechanical and thermal characteristics of a current transformer are fully as important as the accuracy classification. Current transformers of the highest accuracy are usually required only in billing or revenue metering circuits, or in rare cases when extremely exact relaying selectivity is a necessity. It is essential, however, that current transformers in switchgear equipments have mechanical and thermal characteristics that will enable them to withstand the stresses and heating to which they will be subjected while the breakers are interrupting their rated fault currents.

Since the mechanical and thermal ratings of current transformers are not necessarily inter-related, the switchgear engineer gives individual consideration to each rating for each application.

The *mechanical* rating of a current transformer is the maximum amount of current which can be passed through the transformer without causing mechanical damage. This rating is expressed as the RMS value of the a-c component of a fully offset nondecaying sinusoidal current wave. Therefore, when comparing the mechanical rating of a current transformer with the momentary rating of a breaker, it is necessary to multiply the mechanical rating of the transformer by 1.6 in order to add the value of the offset which is inherent in this rating and thus bring the two ratings into comparable terms. In any case where the transformer's mechanical rating multiplied by 1.6 is equal to



ig. 2. Side view of typical
etal-clad breaker unit

or greater than the momentary rating of the breaker in that circuit, the transformer will co-ordinate mechanically with the breaker.

The *thermal* rating of a current transformer is determined by the maximum amount of heat that can be absorbed by that device in a given period of time without damaging the insulation or windings. It is usually expressed as the RMS value of a nondecaying sinusoidal current wave which can be applied to the transformer for a given length of time without causing thermal damage.

The one-second thermal rating of a current transformer is the rating commonly used for comparison purposes in applying such transformers because relay settings on modern systems are almost always so made that a short-circuited line or device will be removed from service in less than this time interval, even if the nearest interrupting device should be inoperative at the moment and an operation of the back-up device be necessary to clear the fault. Therefore, if the one-second thermal rating of the current transformer in question is equal to or greater than the interrupting rating of the breaker in that circuit at circuit voltage, it is considered that the transformer co-ordinates thermally with the breaker.

There are rare instances in which accuracy requirements of a certain circuit may dictate the use of current transformers having so low a continuous current rating that these transformers may not be able to carry the maximum available fault current for a period of one second, even though their mechanical rating will meet the circuit requirements. Whenever a shorter time than one second is used as the basis for the thermal rating of a transformer in comparing this rating with the interrupting rating of its associated breaker, definite assurance is required in each instance that the fault-protective relaying will always clear the circuit in the required time. This assurance is best obtained by the use of instantaneous fault-protective relays for such cases.

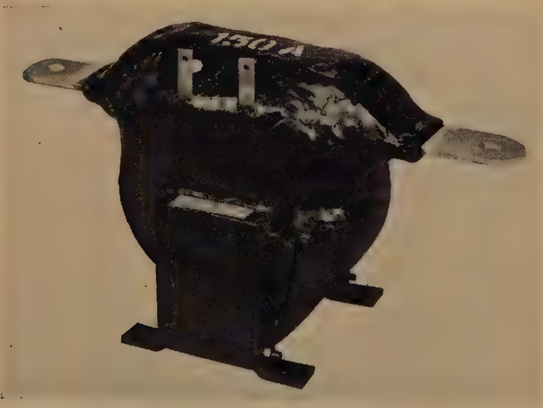


Fig. 3. Current transformer of the type used in metal-clad switchgear

Adequate mechanical and thermal ratings are far more important—for safety reasons—than the ultimate degree of accuracy, but high mechanical and thermal ratings present design problems in current transformers having primary ratings of 100 amp or less. The desig problem is made even more difficult by the defini space limitations imposed on transformers used metal-clad switchgear because the size of a curre transformer is a direct function of both its mechanic and thermal limits and its accuracy. In spite of the obstacles, current-transformer designs have progresse to the point where good mechanical and thermal ratin are available throughout the entire range of standar primary ratings, and all these transformers have a curacy classifications sufficiently high to meet ordinary metering and relaying requirements.

In certain cases where the interrupting rating of th breaker in a particular circuit is higher than necessar because of the voltage class of the system, or for son other reason, the rating of the equipment may be dete mined by the current transformer ratings rather tha the breaker ratings. In such cases, therefore, the tran former selection is based on the system short-circu values instead of the breaker ratings. The user of th equipment, however, should continue to be aware these facts in such an application, because a subsequen increase in system generating capacity might set u available short-circuit currents that would still be wit in the breaker ratings but would exceed the curren transformer ratings.

No current transformer should ever be applied whe its mechanical rating is not sufficiently high to wit stand the maximum duty to which it can be subjecte If current transformers are not mechanically able survive the stresses imposed, they may tear themselv apart under short-circuit conditions, and such an occu rence could easily cause expensive repair bills and lon outages on lines, not to mention the immediate dang to operating or other station personnel.

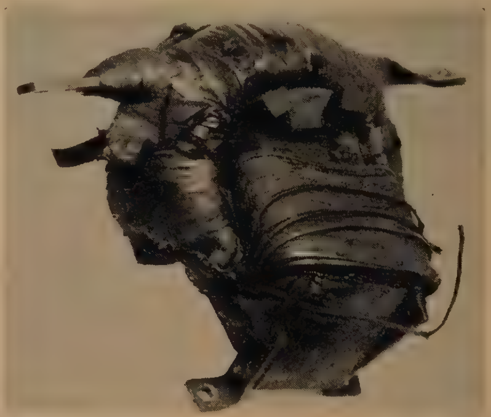


Fig. 4. Current transformer after laboratory test to mechanical destruction

FIG. 3 shows a current transformer of the typ generally used in metal-clad switchgear, and FIG. shows a current transformer of the same general typ after it had been tested to mechanical destructio in the laboratory. The latter illustration well show the risk which is taken when a current transforme is applied in a circuit where its mechanical rating ca be exceeded.

ES

he metal-enclosed bus of standard metal-clad equip-
nt is so constructed that its mechanical and thermal
ings are equal to or better than the corresponding
ings of the heaviest-duty breaker that can be con-
ted to it. Thus, the breaker and the bus assembly
automatically co-ordinated in factory-assembled
tal-clad switchgear.

ES

he fuses for potential transformers in the equip-
nts under consideration are generally mounted on
transformers themselves, and these in turn are
ally set on some form of rollout or drawout carriage.
. 5 illustrates one type of such a carriage with
ential transformers having integral fuse mountings.
th this arrangement, the potential-transformer
ipment can be disconnected from a live bus for safe
tine inspection or replacement of fuses. Since these
es are connected directly to the main primary con-
tors, their ratings should also be carefully con-
ered.

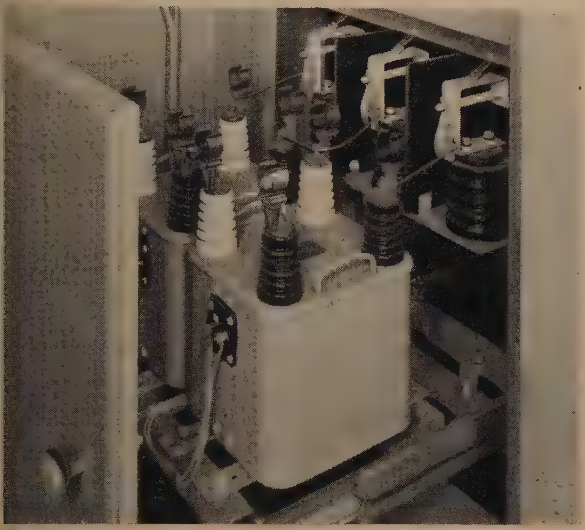


Fig. 5. Rollout carriage with potential transformers. The transformers' fuse mountings are shown but the fuses were not in place when this photograph was taken

he voltage rating of the fuse will match the system
-to-line voltage even if the transformers are con-
ted line-to-neutral. Their interrupting rating is
least equal to the maximum short-circuit current
ilable at their point of application in the system,
their continuous current rating should be as low as
sible in order to afford maximum protection to the
ential transformer itself. At the same time, however,
fuse should be chosen with sufficient capacity so
t it will not blow on the magnetizing inrush current
the transformer it protects. The potential trans-
mers themselves are also connected to the primary
ductors, and consequently are insulated for line-to-
system voltage regardless of their ratio or whether
ir primaries are connected line-to-line or line-to-
tral.

In cases where control-power transformers are mounted in the switchgear to provide a low-voltage a-c power source for closing breakers, or a supply for miscellaneous devices, their fuses will usually also be drawout mounted. Since these fuses, like the potential-transformer fuses, are connected directly to the main system conductors, they will also be of the correct voltage rating and have adequate interrupting capacity. Their continuous current rating should be as low as possible to give good protection, but these fuses should also be selective with fuses on the secondary of the transformer so that faults in individually fused control circuits will not remove the main control power supply by blowing a primary fuse. The control-power transformers themselves are insulated for line-to-line voltage regardless of primary connection and should have a kva rating sufficient to operate equipment connected to their secondaries. In order to provide correct voltage for the control circuits, multiple-tap transformers are usually needed to obtain the proper ratio.

CONCLUSION

To be assured that any switchgear equipment will operate safely and give reliable service—however small the installation—requires both understanding and application of the principles underlying the co-ordination of switchgear components. That co-ordination is best achieved when the switchgear is produced as a factory-assembled unit.

HIGH LIGHTS AND SIDE LIGHTS

Cableways for Hungry Horse Dam

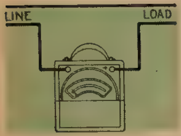
Construction work on the Hungry Horse Dam, the third highest in the world, is progressing rapidly with the use of four powered cableways (COVER). The new $43,000,000 Bureau of Reclamation dam, located on the South Fork-Flathead River in western Montana, will be of arch-gravity construction, approximately 564 ft high, and 2115 ft long on a 1200-ft radius.

Material to be handled in the 2000 days allowed for the completion of the project will include approximately 3,200,000 cu yd of concrete for the dam itself. Because the profile of the valley is especially suited for cableways, these tools are being used for evacuation, for handling concrete buckets, and for placing of machinery.

In the new drive for the fourth cableway, the generator output can be varied from zero to maximum in either polarity to respond to the load requirements. The speed of the motor will follow the voltage, and the direction of rotation will agree with the polarity. Field weakening is provided for obtaining faster speeds when handling an empty bucket. Approximate hoist-rope speeds for the load buckets are 1450 fpm, with the empty bucket being rated 1750 fpm. Approximate carriage-rope speed will be 1200 fpm, which makes these cableways among the fastest in use in the United States. The motor-generator set that will supply d-c power for the cableway motor will consist of one 500-hp synchronous-drive motor, one 300-kw d-c shunt-wound generator, and a 20-kw exciter.

NEW CALIBRATING EQUIPMENT FOR A-C AND D-C AMMETERS

With ease of control, stability of power supply, and convenience of operation, calibration accuracy can be maintained at 0.1% of full-scale values



By S. C. RICHARDSON and W. J. MAXWELL
General Engineering Laboratory
General Electric Company

S. C. Richardson

W J Maxwell

THE tendency in industry today is to require more and more accurate measurements from conventional indicating instruments. Toward this end, more frequent and more accurate calibrations are required, and the increase in accuracy requirements and labor costs can make instrument standardization a very expensive item. Standard calibrating equipment for many years past has made use of storage batteries, large controlling rheostats, and low-voltage high-current a-c generators for this ammeter-calibration work. While such equipment is basically correct, considerable time is required to use it for the calibration of instruments. The unsteadiness of current, whether due to the control means or the power supply source, is very annoying to the operator and consumes time fo accuracy and regulation.

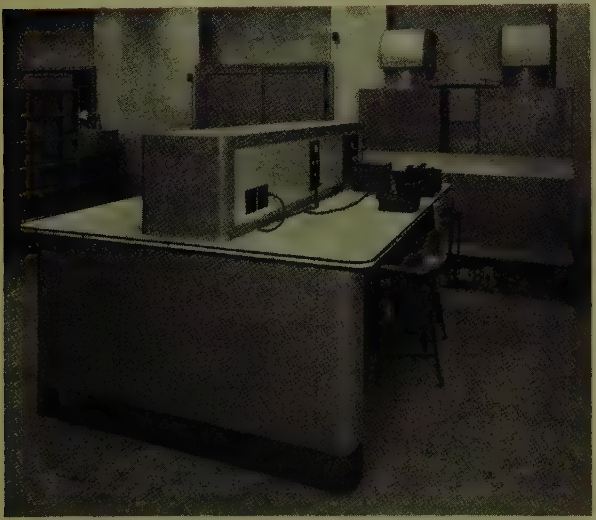


Fig. 1. D-c ammeter-calibrating table, 500–5000-amp range

BASIC EQUIPMENT

Three new calibration equipments have been constructed in the General Engineering Laboratory for th calibration of d-c and a-c ammeters. The first, shown i FIG. 1, has a rating of 500 to 5000 amp d-c. In thi equipment the power is supplied from a bank of phase copper-oxide rectifiers. A motor-driven inductio voltage regulator provides basic control. Current standardization is provided by a water-cooled mangani shunt in conjunction with a null-type potentiometer.

The second equipment, referred to as the 500-am d-c calibration equipment, has a range of 1 to 500 am d-c and is shown in FIG. 2. The power source for thi equipment is also a 3-phase copper-oxide rectifier. Th control is provided by two variable autotransforme in an open-delta connection. The current standardization is provided by a group of shunts used in conjunction with a deflection potentiometer.

The third equipment (FIG. 3), for the calibration a-c ammeters, has a range of ¼ to 200 amp a-c. voltage stabilizer with a filter is used to stabilize th 115-volt 60-cycle supply voltage. The control is provided by small variable autotransformers in the pr mary circuit of the step-down power transformer Current standardization is provided for the range ¼ to 60 amp by the use of a precision current transformer together with a laboratory dynamometer-typ instrument; for the ranges of 100 and 200 amp, by tw portable high-accuracy instruments.

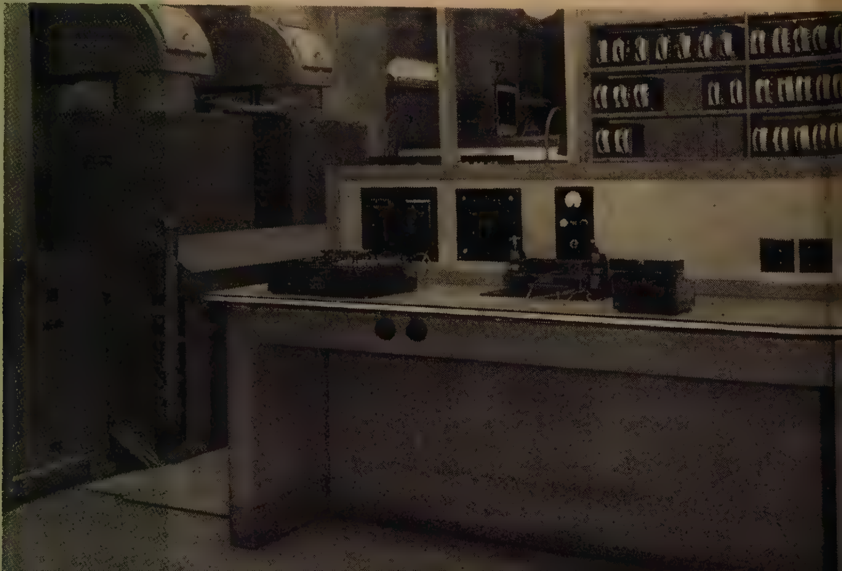


Fig. 2. D-c ammeter-calibrating equipment, 1–500-amp range. Rectifiers for the 500-amp and 5000-amp supply are shown at left

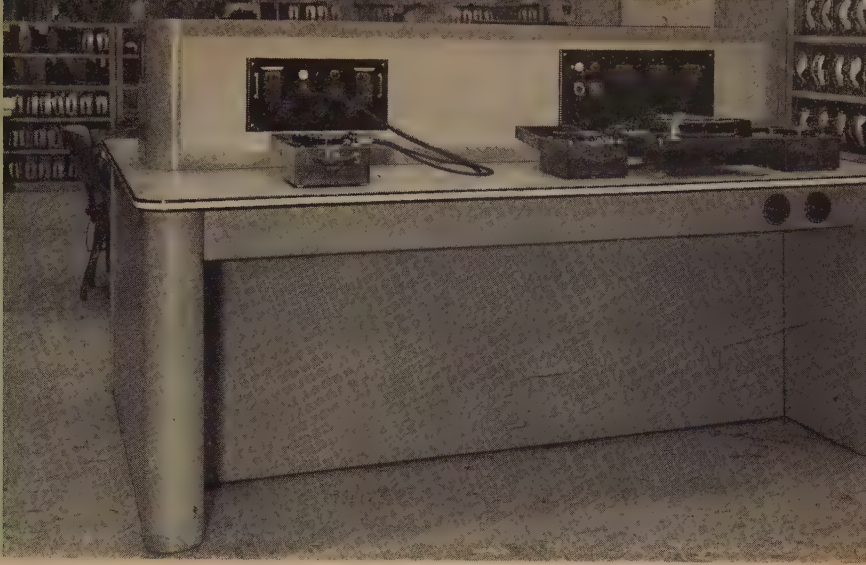


Fig. 3. A-c ammeter-calibrating equipment. Calibration range: 0.25–200 amp

IBRATION TABLES

Considerable thought and attention was given to the ign of the calibrating tables, for pleasing appearance well as practicality. All of the tables are dual-pose so that calibration work can be performed on sides. Wood construction was used throughout for ra safety, and the tables were built in four sections easier assembly. Two of these sections are the les themselves, which are bolted back-to-back. The rd, the central section, holds most of the control ts. The fourth section, not visible in the photo-phs, is a shelf unit under the center of the table to d miscellaneous components such as the shunts, nsformers, and voltage stabilizer.

ccessibility for maintenance and servicing opera-ns is one of the primary considerations in this table ign. All of the equipment located on the shelf tion between the dual table sections is serviceable n either side. The inner partition is hinged at the so that it can be swung up against the table top for rvicing operation. The central control section has a novable inserted cover of pressed hardboard; when cover is removed, the switching and other units in control cabinet are easily serviced. All of the con-l units are of package design, and can be readily re-ved to a convenient location for maintenance or vicing. The tables are six feet wide, eight feet long, the working level is 36 inches above the floor. rk surfaces are covered with linoleum for eye com-of the operators, and the tables are finished in two des of blue-green to conform to the present color ommendations for such equipment.

5000-AMP CALIBRATING EQUIPMENT

he stability of the calibrating current on both of the ammeter calibrating equipments is directly de-dent on the stability of the voltage supply. To elim-e difficulties caused by the instability of the general-pose 230-volt a-c building power supply, this equip-t is connected to the 2300-volt 60-cycle supply. A arate set of 2300/230-volt transformers in 3-phase nection is used for this purpose. With this ar-gement, the stability is normally 0.1 percent.

D-c power for the 5000-amp equipment is furnished by two three-phase plating-type rectifiers with self-contained transformers, blower, air-flow switch, and contactors in addition to the copper-oxide rectifiers. These units have an input rating of 440 volts, 60 cycles and an output of six volts d-c. When connected in parallel their output capacity is 4000 amp d-c for continuous operation. For the intermittent operation required of instrument calibration, they have performed very successfully when loaded up to 5000 amp.

A three-phase motor-driven induction voltage regulator is used as the coarse control. It is rated 20 kva, 220 volts, 60 cycles, with plus or minus 100 percent control. To utilize space, the voltage regulator was located at a considerable distance from the calibrating table and is not shown in the illustrations; a double-throw spring-return switch on the table is used to raise and lower the voltage input to the 3-phase rectifiers. The use of 3-phase rectifiers has eliminated the need for filtering in the d-c output circuit. The output ripple is sufficiently high in frequency and low in magnitude to eliminate the need for filtering. The remaining ripple does not cause oscillation in either the instrument being calibrated or the potentiometer galvanometer.

5000-AMP STANDARD SHUNT

In the design of a 5000-amp shunt, both the air-cooled and the oil-cooled types present definite limitations. Items of primary importance to be considered are: size, effect of thermal emf, and the errors introduced by improper current distribution. A water-cooled shunt was found to have an advantage in all three of these considerations. From previous experience, the size of an oil-filled shunt of this rating would be nearly one cubic yard. The advantage of size in the water-cooled tubular manganin shunt is readily apparent in FIG. 4. The errors due to thermal emf, particularly at the drop terminals, are negligible because of the small temperature differential between them. The errors due to improper current distribution are very difficult to determine and evaluate, particularly in the multiple-strip construction used in most air-cooled and oil-cooled

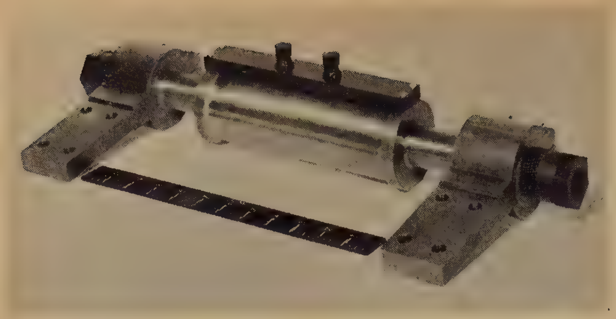


Fig. 4. Water-cooled tubular manganin d-c shunt, rated 5000 amp, 200 mv. The 12-in. scale indicates the compactness of the shunt

shunts. The use of a manganin tube and concentrically formed copper terminals eliminated all the difficulties in this respect: the tube was made from a solid forged piece of manganin alloy, and in the final turning and drilling operations, the concentricity tolerances were held to within 0.0005 inch.

The copper terminals were soft-soldered to the manganin tube. Careful tinning and the use of a silver-tin solder proved highly successful in this operation. The conventional silver-soldering, or brazing, was not used on this joint because of the possible effect of the high temperature on the electrical characteristics of the manganin tube.

The shunt has a resistance of 40 microhms, which is measured at the drop terminals. The manganin tube is eight inches long and the drop terminals are four inches apart. After the annealing process and the final resistance adjustments had been made, the manganin tube was covered with a celluloid cylinder to prevent condensation. The inside of the tube was coated with an insulating varnish.

PROTECTIVE CIRCUIT

The use of a water-cooled standard shunt and forced-draft air-cooled rectifiers made it imperative that adequate protection be provided since failure of water or air circulation could cause very serious damage. A push-button station has been provided for regular starting and stopping operations. If an emergency should arise, the STOP button can be used to de-energize the entire equipment. The START button of this station closes the main-line contactors, starting both blower motors and opening the solenoid valve. A manual switch, water-flow switch, both air-flow switches, and the shunt hood-guard switch are connected in series. All the switches have to be closed to supply power to the rectifiers, and if either the water or air supply fails, a flow switch will de-energize the equipment. The manual switch serves as a means of interrupting power for instrument adjustment without stopping the blower motors and the water supply.

BUSES, LEADS, AND HIGH-CURRENT TERMINALS

Four copper bus bars, ¼ by 4-in., were used in parallel for the 5000-amp circuit, so constructed between the rectifiers and the two terminal clamps that a minimum of bus would be used. This was essential, not only for a reduction in cost, but to redu the voltage drop in the bus structure. One of the te minal clamps is a fixed-vise type, the other a movabl vise type. One jaw on each of these clamps is fixed; t other jaw can be moved by a screw adjustment accommodate the various sizes of bus bars on the shu which is being tested. The movable clamp is connect to the bus structure by a flexible cable that has parallel conductors of 4032-0.005 braided cable. Agai on the terminal clamps particular attention was giv to current-distribution errors. Each vise has the curre supplied through the movable jaw as well as the fix jaw. Permanent drop-lead connections are provided f the shunt under test; these have resistances of 0.0 ohm and 0.065 ohm, which are standard lead resistan values. When a shunt is being tested, the termin clamps and the shunt are under a protective hood. Th hood has an interlock circuit so that the shunt cann be removed when the circuit is energized. Lifting th hood de-energizes the circuit.

With this arrangement of bus structure and clamp it is possible to obtain 5000 amp with a potential three volts. Since the rectifier output is six volts, th leaves a margin of nearly 100 percent for use in speci applications requiring more voltage.

500-Amp Calibrating Equipment

This equipment has a 3-phase copper-oxide rectifi with an input rating of 220 volts, 60 cycles and output rating of six volts at 500 amp d-c. The contr of the 220-volt supply to the rectifier is provided two variable autotransformers connected in open delt The fine control of the output voltage is obtained wi the use of one variable autotransformer and a ste down transformer in one phase. This method unba ances the 3-phase voltages by a slight amount but do not have any adverse effect on the operation of th equipment. The current standardization is provided a set of six shunts and a deflection-type potentiomete The shunts are rated 1.5/6/15/60/150/500 amp.

A unique feature of this equipment is the rota switch provided to change the current connection to th six shunts. Except for its size and rotary constructio it is the same in principle as the taper-type plugs use on the plug-decade type of Wheatstone bridge. Th taper plug is one inch in diameter and one and one-ha inches long. In approximately a year's operation th type of connection has had excellent stability. It ha required only an occasional cleaning and lubricatio with Vaseline. Shunt clamping terminals have been pr vided on top of the table and are adaptable to the va ious sizes of the bus bars of the portable instrume shunts as well as the switchboard shunts with ratin up to and including 500 amp. The rectifier is provide with a fan switch and relay so that it cannot be operate unless the proper air flow is obtained.

AIR FOR RECTIFIER COOLING

An air-duct system has been provided with means f changing from the use of outside air to recirculat

oor air. Outside air is used in summer, and recir-
ted indoor air in winter. Since the rectifier units are
ted in an air-conditioned room, this procedure is
wed so that no additional load is placed on the air-
ditioning equipment. All of these rectifier units are
ted adjacent to a blocked-off window, reducing the
twork required for the inlet and outlet air ducts to
very minimum.

A-c Ammeter-calibrating Equipment

he power supply for the a-c table is provided by the
eral-purpose 115-volt 60-cycle building power
ply, and is connected to a 500-volt-ampere voltage
ilizer with a filtering circuit. This regulated power
upplied to a group of three step-down transformers
ing several secondary connections whose selection
use is determined by the combined impedance of
current-transformer primary and the instrument
ng calibrated. Selection of the proper power-trans-
ner voltage connections and the proper primary con-
tions on the precision current transformer is pro-
ed for by a group of three switches. The control has
in been provided in the primary of the input power
nsformers. To do this, a variable autotransformer is
d for the coarse control and another variable auto-
nsformer combined with a step-down transformer
the fine control.

urrent standardization has been provided by the
of a precision current transformer used in conjunc-
with a five-ampere Laboratory Standard type of
rument. An over-all accuracy of 0.1 percent of full-
e value is obtained by including the average ratio
rection factor in the applied instrument scale cor-
ion. The precision current transformer has primary
ngs of 0.25/0.5/1/2/3/5/10/15/30/60 amp and its
bration has indicated that all primary connections
e the same ratio correction factor within 0.03 per-
t. Change in ratio correction factor is less than 0.02
cent when the secondary load is changed from 10
cent to 100 percent.

he standards for the 100- and 200-amp ranges are
efully selected high-accuracy portable instruments
t have been previously used for a similar purpose
have a calibration history of many years. It is
ved by this calibration record that they have a
ility of 0.1 percent of full-scale value.

everal protective features, both for operating per-
nel and for the equipment have been included in the
gn. Open-circuit high-voltage protection of the
rent-transformer secondary is provided by a Thy-
* resistor. The range-selector switches are of a con-
type with a pull-and-turn operation. When any of
e switches is pulled, the supply to the energizing
y is interrupted; range selection, provided by the
ry motion, is then made in a de-energized circuit.
s prevents arcing on the range-selector contacts.
resistance of these contacts is a very important
or in the stability of the current. The circuit is also
ected from overloading after a range selection is
made. The coarse-control variable autotransformer is provided with a small switch in the zero position which must be operated to close the energizing relay.

Summary

Experience in the use of these three calibration equipments over a period of several months has indicated that the original goal has been achieved. Their ease of control, stability of power supply, and convenience of operation have proved that on all of the equipments the calibration accuracy can be maintained at 0.1 percent of full-scale value. The combination of the protective devices and the simplicity of operation has permitted continuous operation since the equipment was installed, without interruption.

The quietness and cleanliness of the 5000-amp calibrating equipment has made it possible to install it in the same room with many other calibrating facilities. This has saved the considerable time otherwise required for the transportation of the heavy shunts and their instruments to a more remote location of a large rotating generator. The elimination of batteries, rotating generators, and large controlling rheostats has reduced the maintenance of the equipments to the minimum. These modernized calibration equipments have resulted in:

(1). Reduction of the cost of instrument calibration
(2). Reduction of the cost of maintenance and calibration of the standards
(3). Improved accuracy of calibration
(4). Noticeable improvement in the morale of operating personnel.

PROCEEDINGS OF INTERNATIONAL CONFERENCE ON LARGE ELECTRIC HIGH-TENSION SYSTEMS (C.I.G.R.E.) READY FOR DISTRIBUTION

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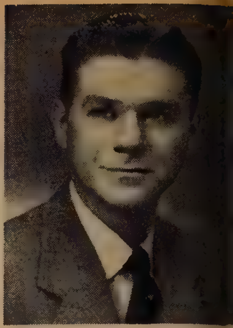
MODERN QUALITY CONTROL

To manufacture at the most economical cost a product that will yield full customer satisfaction is the objective of Quality Control. How it has been developed as an integrated tool and how it is applied effectively in modern manufacture



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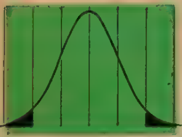

By A. V. FEIGENBAUM

Aircraft Gas Turbine Divisions
General Electric Company, West Lynn, Massachusetts

THE quality-control task which faces management today requires a double-barreled solution:

(1). A considerable improvement must be effected in quality of those products which require such improvement.

(2). A substantial reduction must, at the same time, be made in the costs for supporting and improving the quality of these products.

ORIGINS OF PRESENT-DAY INTEREST IN MODERN QUALITY CONTROL

Why have these quality problems become so serious today? What are the industrial changes that have caused them to arise?

Two developments of the past two decades have impelled management to search for improvements in its older quality-control approaches.

The first development is a technical one. Customers' quality requirements have become far more precise than ever before. The relay that was acceptable in 1939 must perform with much greater accuracy today if it is to serve certain portions of the modern market. The machined part that could once be checked with a pocket scale must now be carefully measured with micrometers or even an air gage.

Material specifications have become more rigid. Tooling has become a more critical factor. "Intangibles" like dust in the air and humidity have now become both extremely tangible quality problems and the objective of elaborate safeguards. Many prewar methods for producing and measuring quality no longer meet present standards.

The second development is a matter of human relations. Plant expansion and war turnover wrought many changes in once stable work groups. Green operators are still the rule of the day in many shops. The road back to pride of workmanship—the core of any successful quality-control program—is one that is neither found automatically nor travelled overnight.

Most product-quality responsibilities were once the exclusive province of the foreman. Some of these responsibilities are now widely scattered among many factory specialists. Poor quality of a part may be due unsatisfactory specifications written by the design eng neer, to faulty procurement by the purchasing agent, inadequate testing by the laboratory technicians, unsuitable processing equipment installed by metho engineering. With modern organizational practic quality control can no longer be exclusively pinn down to the team of the factory foreman and the o 100 per cent "sort the bad from the good" inspecti department.

Management's objective of better quality at low cost is, therefore, complicated by the double-barrel problem of demand for greater product precision on t one hand and by the issues rising from more involv human relations on the other hand. Is management quality objective attainable under present industri conditions?

Practical experience has shown several instanc where just such an objective has been obtained management with a practical, common-sense progra of modern-quality control. To summarize such a pr gram, the experience of the "X Company" will be cite "X Company" is taken to be representative of a typic present-day industrial concern and its experience wi quality control will be brought out by the consideratio of several questions.

QUESTION 1: WHAT IS THE DEFINITION FOR QUALI CONTROL?

Suppose that management of the "X Compan decides to establish a quality-control program. It w want first to outline the scope and responsibilities the new activity. How then is quality control to defined?

Management may immediately encounter a difficu problem. During the past several years, the ter Quality Control has been applied to most of the pr posals that have been advanced for improving produ quality and for reducing the cost of its maintenanc The activity has come to have almost as many defi tions as there have been systems proposed for its use.

Is quality control to refer to a series of sampli inspection methods? Is it to designate the trouble sho ing of factory-reject problems? Is the activity to made synonymous with industrial statistics?

This article is from one of the chapters of the book *Quality Control: Principles, Practice, and Administration*, by A. V. Feigenbaum, just published by the McGraw-Hill Book Co., Inc., New York, and is here reproduced with the permission of the author and the book publisher.—EDITOR.

hese definitions refer to individual methods for
rolling quality. "X Company" management rejects
n as being too restrictive.

conceives of quality as the over-all, factory-wide
ram for attaining management's quality goal. Such
oad program includes many of these individual
nods.

esence or absence of a method like Acceptance
pling Tables may be important to quality-control
tiveness, but it is not considered an indication of
presence or absence of a quality-control program.

X Company," therefore, visualizes quality control
n administrative device. The character of a manage-
t tool like Production Control is felt to be roughly
ogous.

he technique of quality control is seen as a com-
te of sound human relations and effective tech-
gy.

uman-relations activities include, among others,
nizational planning and good administrative prac-
These activities must invoke co-operative, co-
nated activity among the individuals and groups
ged in the production process.

he technical activities must be directed toward
enting defective product quality. They must curb
practice of spending all effort on correcting troubles
r they have occurred.

may be noted that the quality that is being con-
led does not have for management its popular
ning of "best there is." It means "best for some
icular purpose."

oth end-use by the customer and selling price are
ortant among these purposes which establish in-
rial quality standards. Product quality cannot be
ght of apart from product cost.

rap metal may, for example, be the quality raw
erial for a dime-store washer. An extremely expen-
steel may be the quality raw material for a preci-
instrument washer.

X Company" management wants its definition for
ity control to mirror this administrative point of
. It accepts one such as the following:

> *Quality control is the "X Company" system for co-*
> *ordinating the quality maintenance and quality im-*
> *provement efforts of the various groups in the organ-*
> *ization so as to enable production at the most econom-*
> *ical levels that yield full customer satisfaction.*

aintenance of tools so that they will produce satis-
ory parts is felt by "X Company" to be a quality-
rol activity. So is the periodic check of thread gages,
analysis by draftsmen of tolerance-buildups, the use
achine-floor inspectors, the determination of the
racy of machine tools, and the use of sampling in-
tion plans.

more popular, slogan-like version of the "X Com-
" definition might be used. It states that "Quality
rol means co-ordinating the job of making the
uct right the first time at the lowest cost that
les full customer satisfaction."

QUESTION 2: WHAT IS NEW ABOUT QUALITY CONTROL?

Is there anything genuinely new about modern quality control as conceived by the "X Company?" Does it merely represent a new label applied to the reshuffling of well-known techniques?

Modern quality control differs from earlier versions of the activity in two important respects:

First, modern quality control integrates the usually un-co-ordinated approaches to control of quality into an over-all program for a factory. Quality-control activities have, like Topsy, "just growed" during the past decades. The value of an over-all, co-ordinated plan in place of sprawling, disjointed activities is well known in factory administration. This organization of effort is extremely important, if not a single new quality-control method is added to the factory's program. It is even more important if new techniques like the control chart are employed.

The second respect in which modern quality control is different is just this: it may use in its programs a number of new techniques for dealing with, for measuring, and for thinking about the increased emphasis upon precision. Statistics is one of the most useful of these methods. Modern gaging practice is another.

QUESTION 3: WHAT IS A QUALITY-CONTROL PROGRAM?

Now that the hypothetical "X Company" has agreed upon its philosophy of quality control, its next step is the development of actual quality-control activities.

"Our long-range objective is a complete quality-control program for our shops," states "X Company" management. "Let's start by developing such a program for one of our products, an electric snapper."

What is this complete quality-control program? What methods are used in the program? Are its activities confined to inspection work? Are the production and engineering groups involved?

Answers here depend upon the determination of still more basic questions: What affects the quality of the electric snapper? Where is it affected? During design? During machining? In final assembly? How is the quality affected? Who affects it?

Those factors which may have important effects on snapper quality must be controlled if management is to attain its quality goal for the product. It is the consolidation into an over-all program of various techniques for this control that constitutes a complete quality-control program.

The "X Company" electric snapper passes through many hands and processes before it is finally received by the customer. It is merchandised by a marketing group which broadly establishes the product specifications. It is designed by an engineering group which turns these requirements into actual factory standards.

Its materials are procured by a purchasing group, which has an important effect in determining the quality of these materials. The jigs, tools, and fixtures for its production may be developed by a methods group. Parts are manufactured and assembled by a production group.

Materials and life-test performance may be approved by a laboratory group. Conformance to standards is checked by mechanical inspection and electrical test groups. The container in which the snapper will be transported may be developed by a packaging group. The product is placed in its container by a shipping group.

Quality of the electric snapper may be affected at several of these stages in the production process. It may be affected by human beings—operator carelessness, inadequate supervision, poor design, unsound specifications by the sales manager. It may be affected by mechanical factors—inaccurate machine tools, decrepit jigs and fixtures. It may be affected by natural causes—air-borne dust which coats over the snapper contacts, excessive humidity which causes chemical action on the parts.

So a complete quality-control program starts with the design of the electric snapper and does not end until the snapper is placed in the hands of a customer who is satisfied with it. The activities to support this program fall into four natural classifications, termed Quality-control Jobs. These jobs and their definitions are:

(1). *New-design control*, involves the establishment and specification of the desirable cost-quality and performance-quality standards for the product; including the elimination or location of possible sources of manufacturing troubles before the start of formal production.

(2). *Incoming material control*, involves the receiving and stocking, at the most economical levels of quality, of only those parts whose quality conforms to the specification requirements.

(3). *Product control*, involves the control of processed parts and assemblies at the source of production so that departures from the quality specification may be corrected before defective products are produced.

(4). *Special process studies*, involve conducting investigations and tests to locate the causes of defective products, and to determine the possibility of improving product-quality characteristics.

These four quality-control activities gear directly into the four major stages of producing the electric snapper.

Job 1 involves the quality-control work carried on while the snapper is being developed and designed. Tolerance analysis, pilot runs, the setting up and analysis of specifications and standards are a few of the methods that may be used here.

Job 2 concerns the quality-control work carried on while parts and materials for the product are being contracted for and received from outside vendors. Procedures for the procurement and use of the necessary measuring gages and standards, sampling inspection tables, vendor control and records, are a few of the methods that may be used in this activity.

Job 3 is largely conducted in the factory while t snapper parts are being produced and assembl Control-chart technique, machine operation accura studies, tool, jig, and fixture control are a few of t methods that may be used.

Job 4 is involved when troubleshooting is necess on the quality problems which may occur at any sta in the production process. Methods used here incl special studies of factory processes, the analysis of fi reports and complaints, the use of certain statisti methods.

Each of these jobs is supported by a definite routi and the routines are approved by "X Compan management in accordance with a definite plan. Th are part of factory practice just as are producti control or cost-control routines. The existence of th routines and their integration into an over-all syst is the very heart of electric-snapper quality control.

There is a definite approach to the core of th quality-control routines. It is that of *preventing p quality* rather than correcting poor quality after t article has been manufactured.

A major feature of the quality-control jobs is th positive effect in building up operator responsibility and interest in product quality. In the final analysis, is a pair of human hands which performs the importa operations affecting product quality. It is of paramou importance to successful quality control that th hands be guided in a skilled, conscientious, and qualit minded fashion.

QUESTION 4: IS QUALITY CONTROL GOOD ONLY F MASS PRODUCTION?

Suppose that the "X Company" decides to establi quality-control programs for products other than t electric snapper. Will this same framework of activit be applicable to these products? Is it useful for la apparatus as well as small devices, for items built mass quantities as well as those produced in job lo

In the company which carries on both design a manufacture, roughly similar steps must be follow for all products. The articles must be designed; m terials must be purchased; parts must be produce these parts must be assembled. A generally simil quality problem exists at each of these producti stages, no matter what the nature of the product or t quantities in which it is to be built.

In mass-production operations, product quality c be effectively controlled by types of parts, since parts will be made to the same drawing. However, job-lot manufacture, the parts differ from job to j and only the process by which they are produced common to all types of products. Therefore, in ma production manufacturing, quality-control activit center on the *product;* while in job-lot manufacturi it is a matter of controlling the *process*.

So the philosophy and framework and routines m remain comparable for all products. Individual qualit control methods used will, however, vary from prod to product.

TION 5: HOW DO STATISTICS RELATE TO MODERN ITY CONTROL?

wide variety of technical methods is available to the Company" for use in its quality-control program. dustrial statistics is currently the most widely ded of these methods. The statistical approach be simply summarized: Variation in quality char-istics (for example, in diameter of bushings, ness of studs, viscosity of varnish) must be ex-ed among all processed parts, assemblies, and hes. This variation may best be studied by the tion and analysis of small samples of these parts assemblies.

ese sample studies may determine, for a given or material, the amount of variation that is eco-ically acceptable. They may aid in holding to set omic limits the actual variations occurring during uct manufacture.

our statistical techniques may be useful to "X pany" in this work:

(1). *Frequency Distribution*, which is a tally of e number of times a given quality characteristic curs within a sample of product. As a picture of e quality represented by the sample, it may show a glance:

(a). The average quality

(b). The spread of the quality

(c). The comparison of the quality with specification requirements.

ne frequency distribution may be used in such in-ances as the study of the amount of deviation nong batches of foundry sand, and the analysis of e variability in the performance of relays in pre-ipment electrical test.

(2). *Control Chart*, which is an hour-by-hour or y-by-day graphical comparison of actual product-ality characteristics, with limits reflecting the ility to perform as shown by past experience on e characteristics. When the graph's curve ap-oaches or exceeds the limits, some process change indicated which may require investigation.*

ne control chart is useful in such applications as e maintenance of a continuing check on the quality articles produced by machine tools and painting uipments. The chart may also furnish a valuable cord of tool wear or other forms of process shifts.

(3). *Sampling Tables*, which are a series of sched-es for representing, at a given risk, the quality sually expressed in percent defective terms) of an tire lot from a sample properly selected from that lot.

Sampling tables have been useful in some of the more highly publicized quality-control projects. They are of value in replacing expensive 100 percent sorting, and in the establishment for new products of inspection procedures which strike a balance between quality protection and inspection economy.

(4). *Special Methods*, which comprise such techniques as correlation, significance tests, and analysis of variance. These methods have been hewn, for industrial quality control use, out of the general body of statistics.

Special methods are useful in many analyses of engineering designs and process troubles. Will developmental Grid A have a better effect on electronic tube performance than will developmental Grid B? Is hardness of the metal the cause of the breakage of screws being assembled to silicon-steel covers? Is furnace temperature a critical factor in causing variations in casting quality, while metal and furnace atmosphere are relatively unimportant?

Several applications of these statistical techniques have developed into full-fledged technical methods. Process Operational Accuracy Studies are basically a special adaptation of the Frequency Distribution.

One object of process operational accuracy studies is to determine the amount of variation that must be normally expected from a machine-tool operation under a given set of circumstances. With these machine conditions—tooling, materials, coolant—held constant, a sample of parts is produced. The sample is then examined by means of a frequency-distribution analysis.

The conclusions of this analysis may be compared and consolidated with two or three similar studies on the same machine. The final results may be phrased as follows: "Machine 112 has an operation accuracy of +, −0.004 in. on a cutoff operation, on XB5 brass, using as tooling . . . ." With this knowledge, the planner can route metal-working jobs to those machines which are best suited for handling them.

QUESTION 6: ARE STATISTICS THE ONLY QUALITY-CONTROL TECHNICAL METHOD?

While statistics are an important technical method, "X Company" will also require many other technical methods to support a complete program of the quality-control jobs. Here are some examples:

(1). *A New-design Control Method:* Production conditions may result in operators "taking all the tolerance" that is permitted by parts drawings. In assembling these parts, difficulties may develop that had not been visualized when the product was on the drafting board. *Tolerance Analysis* is a basic quality-control method, because it establishes an organized means for determining tolerance buildups while the product is being designed and developed.

(2). *An Incoming Material Control Method:* Variations of one ten-thousandth of an inch among manufactured parts may lead to premature failure of the product while operating in the field. Similarly close

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alternative to the chart means of supervisory control is pro-ed by the electrical Quality Control Indicator. This is a new ice that eliminates the work and time delay involved in nputing periodic records of data and that gives the super-or immediately and continuously the information he needs to able to maintain, at the acceptable level, the quality of prod-s in one or more processing lines. This device was pictured and efly described in GENERAL ELECTRIC REVIEW, March 1950, 10 and 40, and more fully in the article "Quality Control: A w Field for Instrumentation," by T. R. Hand and C. J. Falk, NERAL ELECTRIC REVIEW, July 1950, p. 20.—EDITOR.

measurements may be required for the approval of critical purchased materials. *Precision Gaging* techniques and equipment are a valuable quality-control aid, since they assure the accuracy of measurements of these major characteristics.

(3). *A Product-control Method:* Machine tools, processing equipments, jigs, and fixtures will inevitably wear under constant use. The resulting loose bearings and worn pins may cause poor quality products. A program of *Preventive Maintenance* may be an important quality-control method, since it enables a regularly scheduled examination of processing facilities before they break down.

A host of other quality-control technical methods could be listed. Among them are those useful in product planning and merchandising, in the establishment of guarantees and specifications, in the trouble-shooting of factory rejects and field complaints, and in the control of tools and gages.

QUESTION 7: WHAT IS THE ORGANIZATION FOR QUALITY CONTROL?

With statistics as well as many other methods available for use in the four quality-control activities, the importance of adequate organization of the quality-control program is obvious. The objective of such an organization for "X Company" is the establishment and maintenance of these quality-control activities.

The wide scope of the quality-control organization required becomes apparent from the many phases of the production process affected by these activities. With so many scattered threads to gather together, it is easy to understand why the basic pattern of a successful quality-control organization for "X Company" must be co-ordination of the quality efforts of various plant groups—engineering, manufacturing, sales, inspection. The type of organization indicated by this pattern, in those companies large enough to require it, is a staff group reporting directly to "X Company" top management and supervised by a quality-control head.

This direct line of authority is very important. Without it, the task of co-ordination, control, and the sometimes necessary education of the plant organization would be extremely difficult.

It is not the responsibility of the full-time members of the "X Company" quality-control staff to carry on the various details of the quality-control activities. The men best qualified for this work are those in already existing line and functional groups.

It is the quality-control staff's responsibility to assist in administering the over-all program for "X Company," and to co-ordinate the various product-quality projects. One way of accomplishing this co-ordination is through a quality-control committee, headed by the chief of the quality-control staff and composed of representatives from each of the important groups which enter into the production cycle.

That approach makes it possible to obtain the benefits of quality-control organization with a minimum of full-time expense personnel. "X Company," with fifty-million-dollar annual output and a large wee payroll, can operate its quality-control organizati with one quality-control head and one full-time assista

The actual details of "X Company's" quality-cont organization will naturally differ from that of oth companies, because of variations in products, compa size, personalities, and product-quality history. T program may be assigned to a Quality Control Engine a Quality Manager, a Quality Control Co-ordinator, a Quality Appraisal Supervisor. Organization of eff may be gained through working committees, or throu individual activity. The program may be highly tec nical and complex in some companies, and extreme simple in others.

The common denominator through all these vari tions, however, is that co-ordination and control a the basic pattern, and that the four quality-contr jobs are the functions carried on.

QUESTION 8: HOW SHOULD A MODERN QUALITY-CONTR PROGRAM BE INTRODUCED?

Without the proper attitudes among "X Company" factory personnel, even adequate methods and sou organization cannot assure any degree of success to quality-control program. These attitudes must primarily represented by the very intangible but ve important spirit of quality-mindedness extending fr top management right through to the men and wom at the bench.

Whatever is new about the quality-control progra must gradually be sold to the entire plant, so as to o tain its willing acceptance and co-operation. The stat ment is sometimes made by quality-control personn that their factory organization is "not quality co scious," that it isn't "going along with the qualit control program." This may be largely an admissi by the quality-control people that, in introducing the program, they took into proper account only mecha cal and not human factors.

Without complete top-management support f quality control, no degree of "selling" can be genuine effective. The quality-control program which recei only lukewarm support from management is for doomed to a tough reception and, very likely, to failu

Experience seems to indicate that a program such "X Company's" should be allowed to develop grad ally within the factory. This approach aids in the selli activity and also permits tailoring the general routi to the particular needs of the various shops. It is oft found wise to select two or three troublesome quali problems, to obtain successful results by attacki them, and to allow the four quality-control jobs grow step-by-step in this fashion.

QUESTION 9: WHAT BENEFITS MAY BE OBTAINED FR MODERN QUALITY CONTROL?

When a quality-control program has attained its f growth within a factory, it should be in position carry on all four of the quality-control jobs for the e factory organization. A typical over-all quality- rol application of this sort is one for the "X Com- y's" electric snapper that has been described. A résumé of the control on this device, broken down he four quality-control jobs which were carried on, follows:

(1). *New-design Control:* While the snapper was eing designed and planned, special tests and pilot ns located sources of possible manufacturing oubles, and these troubles were eliminated by de- gn and method changes.

(2). *Incoming Material Control:* Critical dimen- ons were determined and very careful checks were ade of the first lots of parts purchased from ven- ors. From these, the degree of sampling that could done was ascertained. Quality contacts with endors were established and maintained.

(3). *Product Control:* Charts were set up on pro- uction lines showing how many and what percent each part were rejects, so that the factory super- sors could get immediate information as to the resence of quality troubles. Careful attention was aid such factors as preventive maintenance and perator education.

(4). *Special Process Studies:* If the factory super- ision was unable to solve a quality problem, the uality-control organization supplied help from the erson or persons who were in position to be helpful— hether engineering, planning, inspection, labora- ory, or others.

ompared with the previous model of the snapper which no such program had been carried out, this -all quality control aided in obtaining a consider- improvement of product quality, a reduction of 35 ent in manufacturing losses and another 35 percent nspection and testing costs.

The benefits that management may gain from a modern quality-control program are represented in this electric snapper example. Expressed in more general terms, they are:

(1). Improvement in product quality
(2). Improvement in product design
(3). Reduction in operating costs
(4). Reduction in operating losses
(5). Reduction of production-line bottlenecks
(6). Improvement in employee morale.

CONCLUSION

It is thus readily apparent that modern quality control is not a new cure-all which overnight will gain for management its product-quality objectives. Nor is it a substitute for the good manufacturing and engineering practices that have been successful over the years.

It is, however, an increasingly necessary management method to be used in conjunction with these time-honored procedures. It is necessary because existing, un-co-ordinated, individual quality-control techniques are not able to cope with customers' demands for greater precision and the diffusion of quality responsibility, which are the two modern factors that have developed to affect industrial-product quality. Modern quality control attacks these two factors directly—through improved organization for attaining quality objectives, and through more effective use of technical methods.

Properly understood, properly staffed, and above all properly organized, modern quality control is industrial management's tool for pursuing one of its most important objectives: to manufacture products into which quality is built and maintained at the most economical costs that yield full customer satisfaction.

LIGHTS AND SIDE LIGHTS

neling through the Catskills

ectrified equipment is helping to 25 miles through the Catskill Moun- , to add 300,000,000 gallons of water ew York City's water supply by the nsion of the Delaware Aqueduct.

r the first time in tunnel-construction ry, tube rectifiers are being used for notive power. D-c conversion equip- t was required to supply the power for ey operation of the locomotives, used emove the excavated material. The -all dimensions of the equipment are nportant factor, since it is necessary xcavate a space in the tunnel wall ount it; upon completion of the work, space must be filled in with concrete. cause of the restricted working area, 150-kw, sealed-tube rectifier equip- s were specially designed: 176 in. , 52½ in. deep, and 90 in. high. This done by providing a disconnect switch he primary of the transformer, and using a low-voltage anode circuit ker feeding a double-way rectifier.

Protection is provided for the incoming a-c by a breaker at the entrance to each of the working locations. The water-to-air type of temperature-regulating equipment for cooling the rectifier tubes was made an integral part of the rectifier unit rather than a separate component remotely mounted. These rectifiers convert 2300-v 3-phase 60-cycle power to 275-v d-c.

Completely metal-enclosed, the rectifier consists of a Pyranol type transformer with an attached high-voltage primary disconnect switch, a low-voltage anode circuit breaker, heat exchanger, rectifier cubicle, and d-c switchgear.

Fourteen trolley-battery nine-ton combination locomotives have also been purchased. Trolley power will be used to within approximately 1000 ft of the working area; then power will be provided by batteries. The small dimensions of the locomotives—56½ in. wide, 61½ in. high, and 150 in. long—are necessary because of the physical limitations of the tunnel, which is 11 ft 4 in. in diameter.

Electric Brain on Ice

An "electric brain," computer mechanism, is used in remote-control aircraft turret systems developed for bombers. The "brain" shown here is used on the Convair B-36 intercontinental bomber, where it must function under the extreme temperature conditions found at high operating altitudes. The computer is being wheeled into a test cell where the mercury remains at a maximum of −65 F.

SWITCHING OF DISTRIBUTION CAPACITORS BY MANUAL AND AUTOMATIC DEVICES

Switching devices are available for economical use with practically any type of distribution capacitor covering a wide range of frequency of operation

Richard J Hopkins

N. R. Schult

By R. J. HOPKINS and N. R. SCHULTZ

Capacitor Engineering Division
Central Station Engineering Division
General Electric Company

ALL power-factor capacitors are switched occasionally, even the so-called "permanently connected" units which are installed for continuous normal operation. Switching operations vary in nature from exceedingly rare switching of "permanently connected" capacitors for inspection or maintenance to frequent—often several times daily—switching of automatically controlled equipments.

It is well recognized that the major portion of base or unregulated system kvars can be most economically supplied by "unswitched" or "permanently connected" capacitors. For maximum benefits in terms of voltage improvement, loss reduction, and released power system capacity, such shunt capacitor banks are usually located as near to the load as practicable in the distribution system.

Typical of such installations are the small capacitor banks located on primary distribution feeders. In these cases, both short-circuit protection (in case of capacitor failure) and a means of switching can be provided by the use of suitably rated fused cutouts. Use of fused cutouts for occasional manual switching of capacitor banks is considered later in this article.

Basically, the requirement for switching of shunt capacitor banks arises when the kvar supply at time of peak system load exceeds the desirable supply at time of light load. Broadly, the kvars of capacitors to be switched are the difference between peak and minimum load requirements.

The amount of unswitched capacitors which can be applied to a system is limited by these considerations:

(a). Unswitched capacitors should not be applied to the extent that intolerably high voltage levels exist at time of minimum load.

(b). The amount of unswitched capacitors should not be such that system generators will be operated with unduly low excitation from the viewpoint of stability at time of light load.

Since the peak load kvar requirements of many systems may be two to three times the minimum kvar requirement, use of switched capacitors to follow syste kvar load pattern has become a common practice.

In addition to the foregoing broad classificati switched capacitors are also often employed in speci application for the purpose of regulating voltage kvars, and as such are often controlled automatical where manual switching may be inconvenient unreliable. Automatic switching is also used occ sionally to prevent overvoltage or undue losses duri periods of light system load, or when load is sudden lost, or to provide a voltage boost during time of lo voltage caused by a system disturbance.

APPLICATION AND TECHNICAL ASPECTS

De-energizing Problem

The problem of interruption of capacitive curre has already been presented in technical papers.(1) Th brief description of the phenomena associated wi interruption of capacitive current included here is f the sake of completeness.

A simplified single-phase circuit, as shown in Fi 1 (a), can be used to illustrate the basic problem interruption. It is ordinarily assumed that curre interruption will take place at the first normal curre zero following separation of the switch contacts. In capacitive circuit this corresponds to a maximum crest value of system voltage as shown in Fig. 1 (b At the instant of interruption, the voltage across th switch is zero since the capacitor on one side of th switch holds the same crest voltage that existed ju prior to interrupting. Since no initial voltage appea across the switch, any circuit breaker or switch wi interrupt quite easily at the first current zero followi contact separation. However, as shown in Fig. 1(b following interruption, voltage begins to appear acro the switch due to the alternating system voltage un it reaches a value of twice normal crest voltage ju one-half cycle after interruption.

If the switch successfully withstands this doub voltage without restriking, the interruption can termed successful. If, however, the switch restrikes or near the time of double voltage, the capacitor volta can reach a value of approximately three times norm

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This article was presented as a paper at the AIEE Winter General Meeting, New York (N. Y.), January 22–25, 1951.

(1) Numbered references are listed at end of the article.

; value. It is theoretically possible to compound essive clearings and restrikes in such a manner as ield circuit voltages of many times normal value. vever, extensive field tests by other investigators shown that overvoltages due to restriking seldom, ver, exceed three times normal voltage.⁽¹⁾

his brief description of capacitive current interrup- should be adequate to illustrate the point that the rupting capacity of circuit breakers and other ches on capacitive circuits may be limited in com- son to the rating assigned for "normal" load or t-circuit current interruption. It should be empha- l that capacitive current interrupting limitations usually assigned on the basis of limiting transient voltages to approximately twice normal voltage. limitations are not usually indicative of the ty of the switch or circuit breaker to eventually the capacitive circuit.

ractically speaking, many types of circuit breakers switches are commercially available for switching citive current. Their ratings and suitability for type of service have been determined by experience comprehensive tests.

rgizing Problem

has been shown that the inrush current to a citor bank is a function of the bank rating and lable system short-circuit current.⁽²⁾ Generally this sient inrush current is of very short duration, g highly damped by inherent circuit resistance, and a frequency many times greater than normal system uency. Experience with nearly every type of ca- tor switch has indicated that inrush currents asso- ed with capacitor banks are not harmful to the ches and do not constitute a problem.

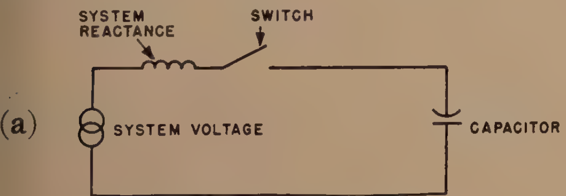
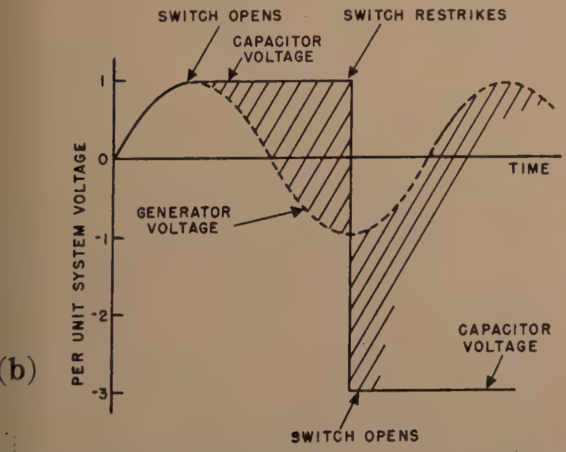


Fig. 1(a). Simplified single-phase circuit



1 (b). Voltage appearing across switch contacts during opening of iit to a capacitor bank. Height of shaded area at any time represents ch voltage

Proper Switch Selection

In selecting switches for capacitor banks, the following requirements should be met:

(1). Voltage Rating. The voltage rating of the switching device must be equal to or greater than the normal voltage of the circuit to which the equipment is to be connected. Both the 60-cycle potential test and impulse voltage test levels of the switch should be consistent with those of other apparatus in the same voltage class.

(2). Continuous-current Rating. The continuous-current rating of the switching device should be at least 135 percent of rated capacitor-bank current in accordance with NEMA Standards for shunt capacitors. Capacitor-bank currents may exceed rated or nameplate values because of the plus manufacturing tolerance on the capacity of individual units and because of the possibility of overvoltage and harmonic current flow. The 35 percent allowance factors in these considerations.

(3). Interrupting Rating. If the switching device is used as a means of short-circuit protection in addition to its duty as a capacitor switch, it must, of course, have an interrupting rating adequate to handle short circuits occurring in the equipment on the capacitor side of the switch.

In any event, whether the switching device is used for short-circuit protection or not, it must be able to interrupt the normal capacitor current without excessive transient overvoltages due to restriking.

If the switching device has no short-circuit interrupting rating of its own, protection against short circuits in the capacitor bank must be provided by other means. Capacitor units may be fused individually, or in groups; or the entire capacitor bank and bus work may be protected by line fuses, cutouts, or circuit breakers of adequate interrupting rating.

When applying fuses, it is necessary to limit the fuse link size so that, should failure of an individual capacitor unit occur, that unit will be promptly removed

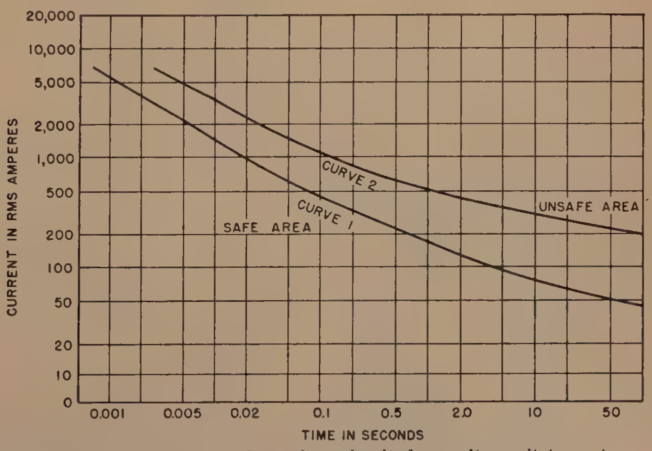


Fig. 2. Current vs. time for a short-circuited capacitor unit to rupture by gas pressure after an internal short-circuit occurs

Area below Curve 1 is safe with no damage other than slight swelling expected
Area above Curve 2 is unsafe. Rupture will occur frequently with possible damage to adjacent capacitors.
Area between curves is region of doubtful operation. Slight case rupture and cracked bushings may occur.

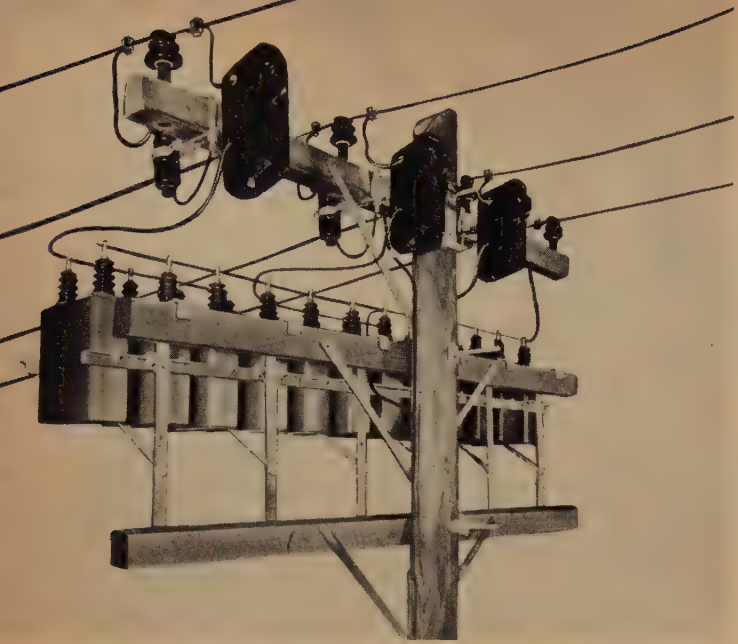


Fig. 3. A typical application of three 5200-volt 100-amp cutouts on a 300-kvar 4160-volt capacitor bank

from the circuit. The fuses used should have total clearing times no greater than those given in Curve 2, Fig. 2,(3)(4) which shows the characteristic of current vs. time for an internally short-circuited capacitor unit to rupture by gas pressure after an internal failure occurs. Attention also should be given, of course, to the co-ordination of these individual fuses with any sectionalizing fuses which may be in the circuit.

(4). Momentary Current Rating. The switching device must have sufficient momentary current rating to adequately withstand system short-circuit currents for faults at its terminals. This consideration must be met even though the device is not used as a means of short-circuit protection.

(5). Frequency of Operation. The mechanical and electrical design of the switching device should be such that it will withstand a reasonable number of operations without undue maintenance. This m require special consideration in some cases involv a number of switching operations each day.

Switching devices fall into several distinct types pending on whether they are to be manually operat or are to be actuated by automatic control devices.

Manual switching devices are usually used wh switching is infrequent and the cost of electrica operated devices cannot be justified. Electrically op ated and/or automatically controlled switches are us where frequent operation, up to several times a d is required. These devices fall into further subdivisio depending on the short-circuit capacity of the syste the length of life required without maintenance, a the size of the capacitor bank to be switched.

Switches of all of these classes are considered in mo detail in what follows.

MANUAL SWITCHING OF CAPACITORS

The device most commonly used for manual swit ing of capacitors is the fused cutout. This device al provides short-circuit protection for the capacitor i stallation within the limits of the relatively low int rupting ratings of these devices.

The successful switching of capacitors with air-bre devices such as fused cutouts depends to a considera extent on the experience and technique of the operat and the speed of opening. Until recently, publish tables of capacitor-bank sizes that could be switch by various cutouts were extremely conservative, judg by information from various utilities.

In order to obtain more factual data on switching capacitors with cutouts, a series of tests was recent made to determine the actual limiting current that t various cutouts can open successfully. Tests were ma on all of the various types of open and enclosed no repeating cutouts manufactured by the General Electr Company.

TABLE I: GUIDE FOR THE APPLICATION OF FUSE CUTOUTS WITH CAPACITOR BANKS

	Cutout Ratings			Rated Capacitor Kvar, 3-phase, 60 Cycles, That Can Be Switched					
Type of Cutout	Volts	Amperes	Interrupting Rms Amperes	At 2400 Volts Delta	At 4160 Volts Delta	At 4160 Volts Grd. Y	At 4800 Volts Delta	At 7200 Volts Delta	At 12,470 V Grd. Y
ENCLOSED-TYPE EXPULSION CUTOUTS (WITH FUSES)									
Nonindicating	5200	50	1200	125	225	225	160	—	—
Indicating and Dropout	5200	50	1200	125	225	225	200	—	—
Nonindicating	5200	100	3000	190	275	330	160	—	—
Indicating and Dropout	5200	100	3000	190	300	330	200	—	—
Nonindicating	7800	50	1200	125	225	225	160	80	140
Indicating and Dropout	7800	50	1200	125	225	225	200	120	200
Nonindicating	7800	100	3000	190	275	330	160	65	115
Indicating and Dropout	7800	100	3000	190	300	330	200	160	280
Heavy-duty Indicating	5200	100	5000 @ 5.2 Kv	190	240	330	100	—	—
Heavy-duty Indicating	5200	200	8000 @ 2.5 Kv	190	275	330	160	—	—
OPEN-TYPE EXPULSION CUTOUTS (WITH FUSES OR DISCONNECTING BLADES)									
Dropout	5200	100	2000	190	240	375	100	—	—
Dropout	7800	100	2000	190	240	375	100	55	95
Dropout	15,000	100	2000	—	—	—	—	40	65

l tests were made on a single-phase circuit, indoors ill air. Cutouts were opened manually. As criteria successful switching it was decided that the par- ar current must be opened on ten out of ten trials, the resulting arc rising not more than one foot e the cutout. Capacitor-bank sizes were increased var at a time until a current was reached which d not be successfully switched.

om results of these tests, Table I was compiled. table gives the three-phase capacitor kvar which be switched under the conditions stated, for all the mon types of nonrepeating cutouts. Operating rience may indicate that experienced operators can essfully switch larger bank sizes. During the tests, -type cutouts were successfully used to switch er capacitor banks, but with a considerably greater of the arc above the cutout. Thus, in locations where e are no circuits or other limiting structures above cutouts, open-type cutouts could be used to switch er banks of capacitors than those shown in the table.

l of the cutouts listed have current-carrying capa- s double those listed under "cutout ratings" if a onnect blade is substituted for the fuse holder. With onnect blades, larger banks than those given in le I can be switched at 2400 volts Δ and 4160 volts nded Y by enclosed cutouts only as follows:

Voltage	*3-phase kvar*
2400 volts Δ	375
4160 volts grd. Y	650

hese cases individual capacitors should be fused to ect against short circuits that might occur at the ant of switching and cause a hazard to the operator. compiling Table I, certain rules were observed h are indicated below.

). Fuse link sizes are limited to 50 amp (N) for mp cutouts. For the 100- and 200-amp cutouts, the link rating is limited to 75 amp (N) to avoid ting a capacitor container in case of failure of a citor. These fuse link ratings are at least 165 percent e normal rated capacitor current as recommended EMA Standards for shunt capacitors.

). Where the maximum current switching ability s than the maximum fuse sizes as determined in (1), capacitor bank size was determined by making an vance for overloads due to voltage, harmonics, and capacity encountered under average operating itions.

typical installation of pole-mounted capacitors, ected by enclosed cutouts, is shown in Fig. 3.

so available from various manufacturers are a ber of types of air break switches which may be for manual switching of capacitors.

ypical of these devices are those in Figs. 4 and 5. g. 4 shows a fused disconnect switch, available in gs of 100 amp at either 7500 or 15,000 volts. The r end of the fuse link is held by a trip mechanism e upper end of the fuse tube. When it is desired to onnect the capacitor bank the trip lever at the upper end of the fuse tube is tripped by means of a switch stick. This releases the fuse link which is pulled out of the fuse tube by spring tension. The resulting arc is extinguished inside the expulsion tube. To return the bank to service, the entire expulsion tube is removed, refused with the same link, and the circuit closed by replacing the expulsion tube.

Tests have shown this device to be capable of interrupting 100 amp at 15,000 volts without restrikes. As stated before, the maximum fuse link size should be no greater than that equivalent to the limits indicated in Curve 2 of Fig. 2. This corresponds to the characteristics of a 75-amp (N) cable-type fast-blowing fuse link. Otherwise protection from case bursting in the event of a capacitor failure must be provided by other fuses.

Fig. 5 shows a disconnect switch with a special arc interrupting chamber. The manufacturer's tests indicate that this device will interrupt 400 amp capacitor current at 15,000 volts without restrikes.

The expulsion tube in the arc interrupter must be replaced after the following number of operations:

Amperes Switched	*Operations*
400	25
200	50
100	100

With this device also, short-circuit protection must be provided by other means.

A mechanism can be added to improve the switching ability of some open-type cutouts. With this device in place, it is possible to break the fuse link inside the expulsion tube by means of a switch stick. Interruption of current takes place inside the expulsion tube. Thus capacitor banks of sizes up to the maximum that can be

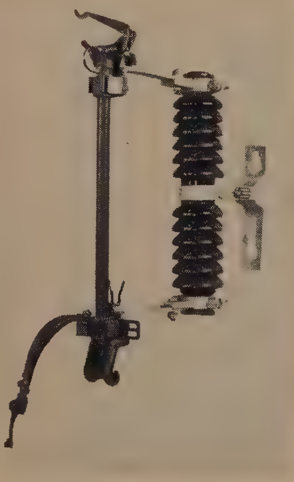


Fig. 4. Fused disconnecting switch rated 100 amp, 15,000 volts

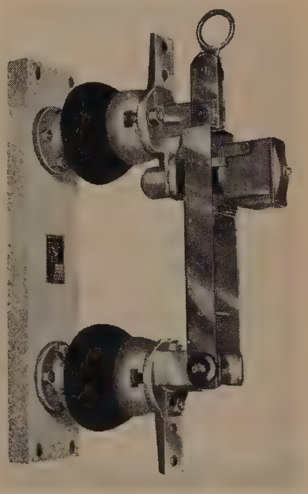


Fig. 5. Disconnecting switch rated 400 amp, 15,000 volts, with special arc interrupting chamber

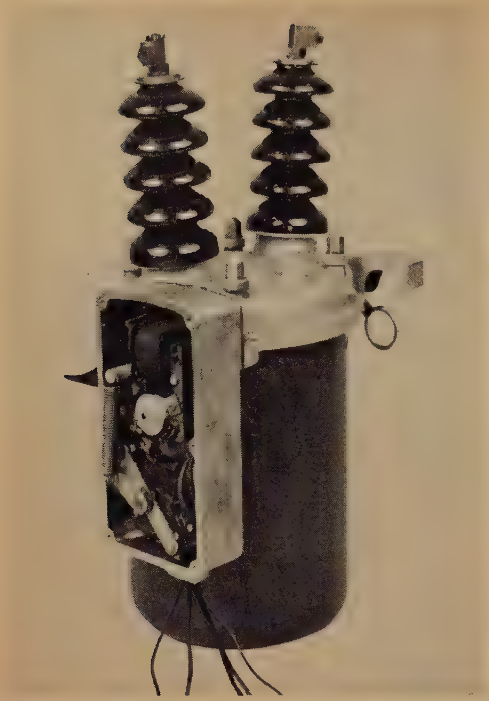


Fig. 6. Single-phase oil switch rated 100 amp, 15,000 volts. This view shows the operating mechanism

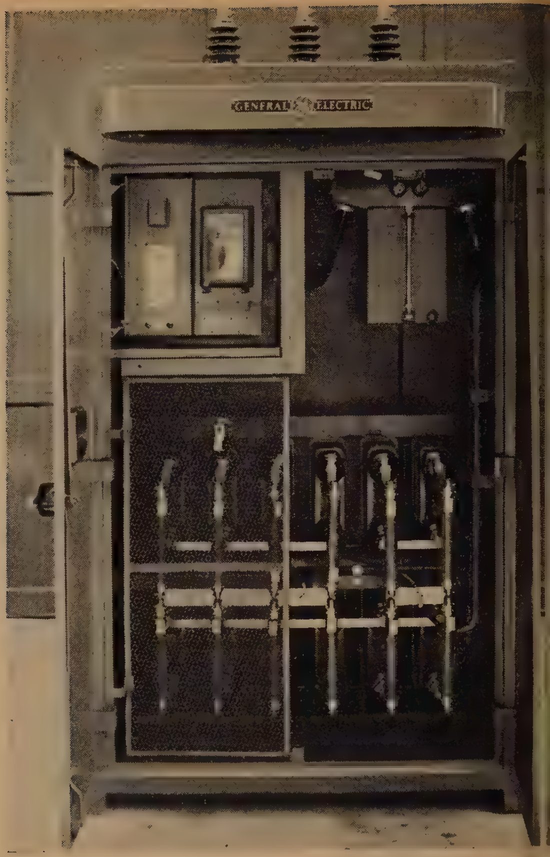


Fig. 7. Typical installation of an oil switch on a capacitor bank rated 180 kvar, 4800 volts, three-phase

carried on a 75-amp link can be successfully switched without restrikes with this device; but each switching operation, of course, expends three fuse links for a three-phase capacitor bank.

In certain locations, such as indoors, the open arc obtained when switching with ordinary cutouts may be undesirable for safety reasons. In these cases oil-fuse cutouts may be used. These cutouts are subject to the same maximum fuse link size to prevent case bursting in the event of capacitor failure as are open and porcelain-clad cutouts. In general, oil-fuse cutouts are capable of successfully switching the same bank sizes as corresponding ratings of porcelain-clad cutouts.

For applications where more frequent manual switching is required but where automatic or remote contro not necessary, an oil switch similar to that shown FIG. 6 is applicable, except that the motor operat mechanism is omitted. This switch is rated 100 am 15,000 volts, single pole.

The continuous and momentary ratings, and cont life of this switch are given in Table II. The thr phase capacitor bank sizes that can be switched wit set of three switches are given in Table III. This swit also, has the advantage over most air break devi that the arc is completely enclosed. This is a decid advantage where adjacent apparatus or circuits, possible hazard to the operator, make an open inadvisable.

TABLE II: COMPARISON OF OIL SWITCH CHARACTERISTICS

Switch	Rated			Momentary Amperes	Basic Impulse Level (kv)	Contact Life
	Volts	Amperes	Phase			
(Fig. 7)	7500	See Table III	3	5000	75	10,000 Operations at 180 kva or 5,000 Operations at 225 kva
(Fig. 6)	15,000	100	1	5000	95	6,000 Operations at rating
(Fig. 8)	15,000	150	3	40,000	95	45,000 Operations at 100 amp 20,000 Operations at rating

TABLE III: ALLOWABLE SIZE OF CAPACITOR BANKS—KVAR

Switch	2400 V.	4160 V. Delta	4160 V. Grd. Y	4800 V.	7200 V.	12,470 V.	13,80
(Fig. 7)	225	225	300	225	225	—	—
(Fig. 6)	300	530	530	600	920	1600	176
(Fig. 8)	450	800	800	900	1350	2400	270

OMATIC SWITCHING OF CAPACITORS

or locations where automatic switching of capacitors quired, switching devices are available for low-cost ching of distribution capacitors in response to nges in current, voltage, or other load character- s. These switches fall into two distinct classes:

). Switches for use on circuits where low short-circuit currents are available

). Switches for use on circuits where high short-circuit currents are available

n the first class are the switch shown (installed in a acitor housing) in FIG. 7 and the one in FIG. 6.

he former is a three-phase, three-pole oil switch, rated 0 volts maximum. It is capable of switching bank sizes o 225 kvar 3-phase at delta voltages up to 7200 volts 0 kvar can be switched at 4160 volts grounded Y). s switch has a basic impulse level of 75 kv and can y currents up to 5000 amp for 6 cycles without ex- ive burning of contact tips or other damage.

ontact life is about 10,000 operations, close and open, 80 kvar and about 5000 operations at 225 or 300 kvar. should be changed at the same time as the contacts. chanical life is in excess of 40,000 operations.

his switch is solenoid operated with the solenoid rgized in the closed position. With a 110-volt coil, coil holding current is about 1.9 amp with an inrush bout 13.5 amp.

typical application of the switch to a 180-kvar bank apacitors is shown in FIG. 7.

he switch shown in FIG. 6 is a single-phase one-pole switch rated 100 amp, 15,000 volts. Three of these tches are required to switch a three-phase capacitor k. This switch has a basic impulse level of 95 kv and can carry currents up to 5000 amp for 15 cycles without excessive burning of contacts or other damage. Contact life is about 6000 operations at full rating. Because of the small oil volume, oil should be changed at about half the contact life to maintain the full insulation level across the open contacts and between poles. Mechanical life is in the order of 10,000 operations.

This switch is operated by a motor-wound spring mechanism, providing snap action opening and closing. The motor is energized only during actual operation of the switch.

Capacitor bank sizes that can be switched with this switch are given in Table III.

For circuits where high short-circuit currents are available, or where a sturdier longer-lived switch than either of these two is desired, the type of switch shown in FIG. 8 is available. This is a three-pole oil switch rated 150 amp at 15,000 volts. The resulting bank sizes that can be switched at the various voltages are given in Table III.

This switch is designed on the principles of the well-known load-ratio-control mechanism for on-load tap changing in transformers. Snap action open and closing of contacts is provided by a motor wound spring mechanism. The motor is energized only during actual switch operation. The switch has a basic impulse level of 95 kv and has a standard momentary current rating of 40,000 amp, including d-c component. Contact life is 45,000 operations, close and open, at 100 amp or 20,000 operations at 150 amp. Oil should be changed with contacts. Mechanical life is in excess of 100,000 operations.

FIG. 9 shows a typical application of the switch in a 900-kvar capacitor equipment.

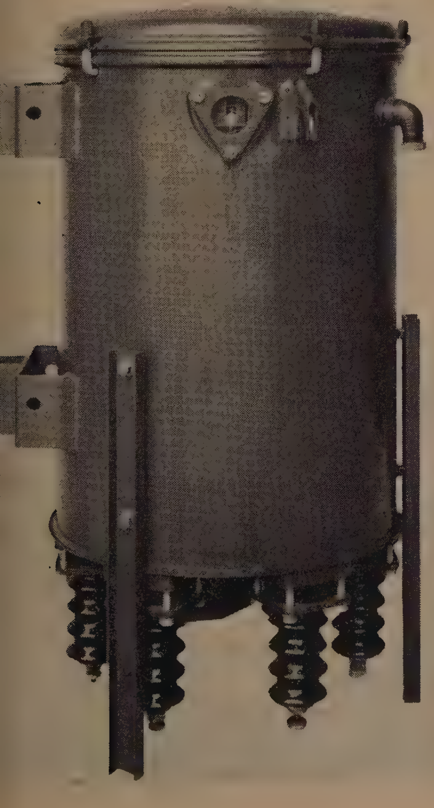
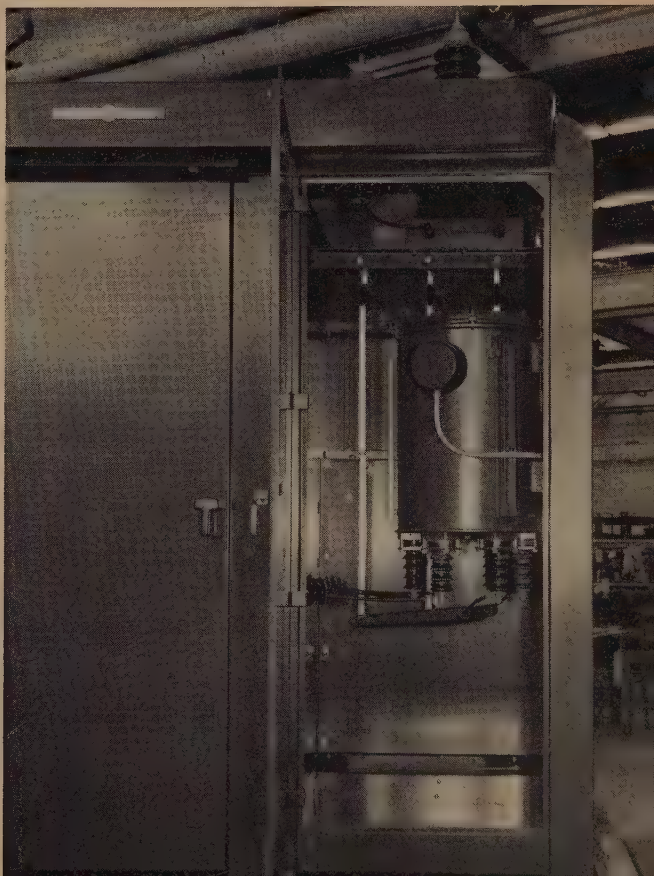


Fig. 8. Three-phase oil switch rated 150 amp, 15,000 volts

Fig. 9. Typical installation of switch of the type shown in Fig. 8 in switch compartment of a 900-kvar 12,470-volt three-phase capacitor equipment



Ratings and characteristics of the three oil switches described are given in Table II. The capacitor bank sizes that can be switched by the various switches are given in Table III. This table was calculated taking into account the rule that the switch rating should be 135 percent of the rated capacitor current as previously pointed out.

All three of these oil switches have no short-circuit interrupting rating in excess of their nominal current rating. Protection against line or bus faults in the capacitor bank or against case bursting in the event of a capacitor failure should be provided as previously described. All of these switches will interrupt their rated capacitor current at their rated voltage without restrikes.

The automatically controlled switching devices presented thus far were designed specifically for capacitor switching. The first two switches are intended to fill the need for a low-cost switching device for comparatively light duty. The third switch, while more expensive than either of the other switches, is a heavy-duty device and still has a lower cost than standard circuit breakers. In addition, its long life before requiring maintenance is a decided advantage over circuit breakers. Breakers are not designed for frequent operation and require more frequent maintenance than this switch.

However, where bank sizes in excess of those listed in Table III must be switched, circuit breakers must be used. Standard 15-kv air breakers are available which will switch up to 30,000 kvar of capacitors. Standard 15-kv oil circuit breakers are available which will switch up to 10,000 kvar of capacitors. Other 15-kv oil breakers can be modified so as to be suitable for switching up to 30,000 kvar of capacitors. Since these devices are not designed specifically for capacitor switching, freedom from restrikes is not certain. However, within the kvar limits given, transient overvoltages on switching will not exceed twice normal, and will cause no trouble.

TYPES OF CONTROL

Various types of control systems are available for operating motor- or solenoid-operated switches in response to changes in circuit conditions.

The most commonly used control is voltage sensitive, so that capacitors are switched on at times of low voltage and off when voltage is normal or above. This type of control cannot be used in locations on the source side of the control point for induction or step-voltage regulators. In these locations, voltage tends to be highest at time of heaviest load so that the capacitors will be off when most needed. Current or current-compensated voltage controls should be used in these locations.

A voltage-sensitive control panel, to control a switch applicable for low short-circuit currents is shown in Fig. 7.

Another common type of control is sensitive to line current. The capacitor will be switched on when line current exceeds a predetermined value.

A third type of control is voltage-sensitive but cr rent compensated. For all values of line current bel the predetermined value, the control acts as a straig voltage control. When line current exceeds the pr determined value, a relay closes, changing the calibr tion of the voltage-sensitive device by inserting a ser resistor. In effect the voltage sensitive device "sees" lower voltage, switching on the capacitors. For values of current above the predetermined value, t capacitors will be on unless the circuit voltage rises hi enough to offset the change in calibration of the voltag sensitive device. An advantage of this control over t straight current control is that during periods of l voltage due to system disturbances, the capacitors w be switched on and will stay on until the voltage normal, regardless of current. Thus capacitor kilova are always on the system when most needed.

Control is available which will switch capacitors response to changes in the reactive kva flowing in th circuit. This is commonly called kilovar control. Th control is relatively expensive and has little advanta over current-compensated voltage control.

Controls can also be supplied responsive to tim where a load cycle is well enough known to make switc ing at definite times each day feasible.

Time modification can be added to current, voltag current-compensated voltage, or kilovar controls allow omission of any part of the week from automat operation.

All control systems except straight time and curren controls can be supplied to switch capacitor banks steps. One switching device is necessary for each ste Up to five steps are available in standard controls, an six-step controls have been supplied. Step controls ca be provided with sequencing devices which provide f approximately equal service on all switches and capa itors. That is, over a period of time, all switches operat for part of that period as Step 1, then as Step 2, etc.

In conclusion, it can be stated that switching device are available for switching economically practically an type of distribution capacitor. These cover the range switching frequency from the once-a-year switching f inspection purposes to the three or more switchings p day of automatically switched capacitors. Contr systems are available for automatic control of switchin in response to almost any load variable.

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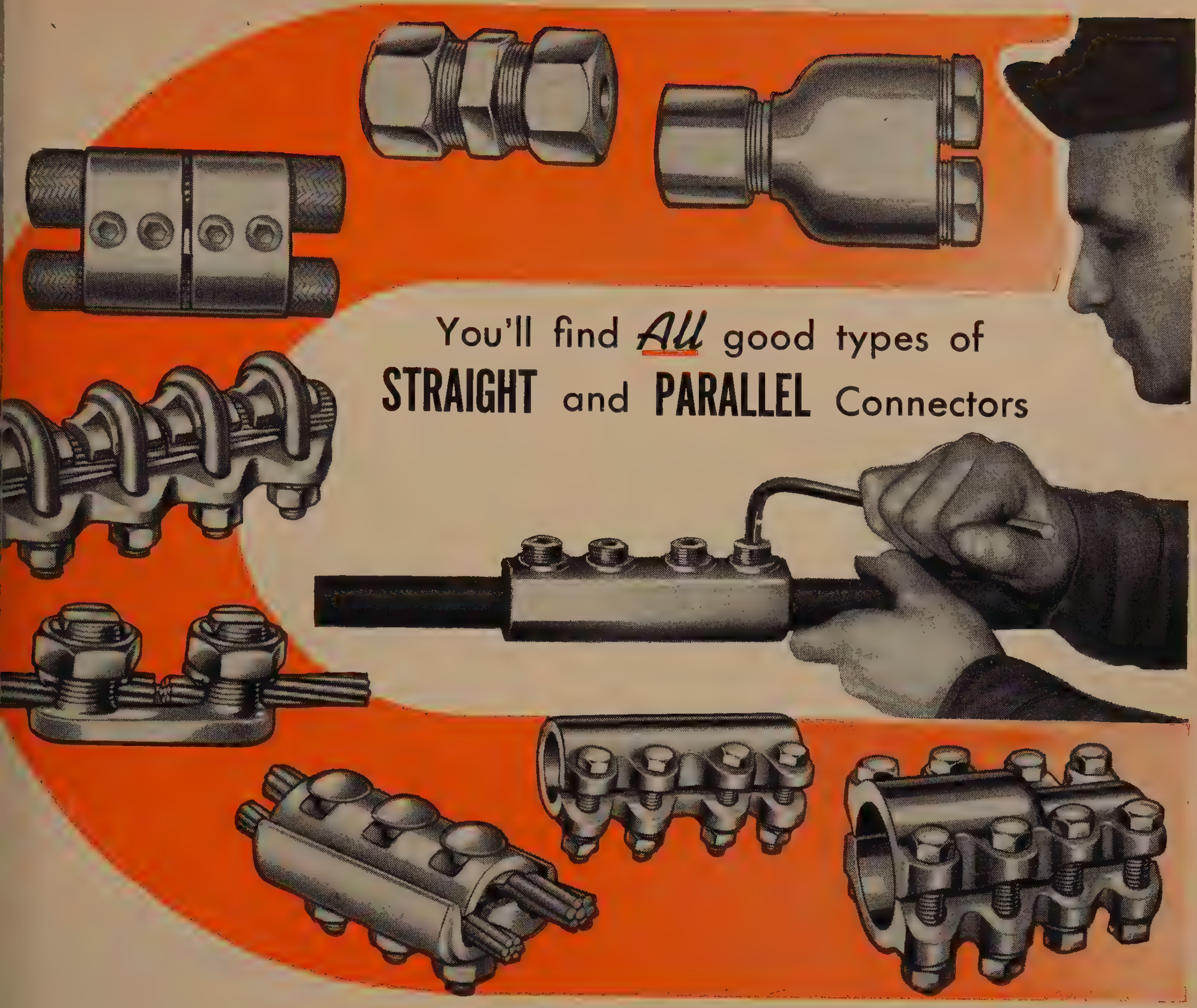
(3)"Report on the Operation and Maintenance of Shunt C pacitors." Working Group of the AIEE Subcommittee on Capa tors of the AIEE Committee on Transmission and Distributio *AIEE Transactions*, vol. 68, 1949, Part II, pp. 1152–1163.

(4)"Connection Arrangements and Protective Practices for Shu Capacitor Banks," by N. R. Clark and S. B. Farnham, *AIE Transactions*, vol. 68, 1949, Part II, pp. 1164–1166.



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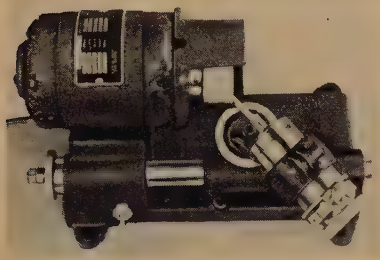
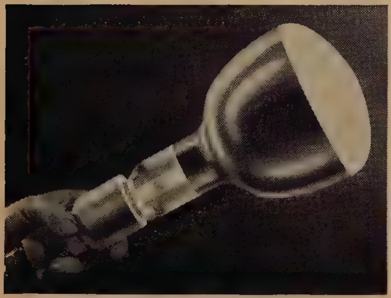
Dehydrators



Cutter Grinder



High-bay Lamp

High-bay Lamp

Two high-wattage industrial lamps with built-in reflectors for use in the lighting of high-bay factories. Because almost no dirt collects on the bottom of the bulbs—the only place where light is emitted—the lamps are suitable for use in foundries, welding ships, and other locations in which dirt collection normally causes severe reductions in light levels. Also, they are advantageous in high-bay areas where lamps can be reached for maintenance only at high cost, or interfere with production. Produced in both 500- and 750-watt sizes, the lamps utilize a new bulb design, the R-52, having a special contour to distribute the light downward for effective use in the working areas, and a cutoff to give reasonably comfortable brightness down to 35 deg below the horizontal.—*General Electric Co., Lamp Department, Nela Park, Cleveland, Ohio.*

Potentiometer

An accurately calibrated 0 to 100,000-ohm linear potentiometer, called the Selectohm, for use as a resistance substitute for service or laboratory work. This device provides a rapid means for determining the values of blackened burned-out resistors when it is substituted in radio, television, and other electronic circuits. The unit is also useful for laboratory work because it can be used to replace a decade box. The instrument serves as a precision rheostat, shunt, or multiplier. It is rated 25 watts. —*Chicago Industrial Instrument Co., 536 W. Elm St., Chicago 10, Illinois.*

Dehydrators

Auto-dryaire dehydrators for pressurizing transmission lines, wave guides, and associated apparatus. This line of equipment offers automatic, continuous operation and delivery of air at lowest dew point. Model 105–107, largest of the line, is capable of delivering air for servicing volumes up to 200 cu. ft. This dehydrator, with an output of 3 cfm, is designed to purge and pressurize the largest wave guide and transmission-line installations.—*Communication Products Co., Inc., Keyport, New Jersey.*

Cutter Grinder

An accurate and inexpensive precision cutter grinder for sharpening engraving cutters. So simple and practical is the design of the grinder that convenience and ease of operation are assured even to inexperienced workers. An outstanding feature of the device is the index unit on the spindle which allows the operator to grind any desired cutting profile with proper angles and clearance. Two-, three-, and four-fluted cutters can also be ground and sharpened by using an attached indexing plate. Equipped with a cool-cutting grinding wheel, the device has an adjustable clamp head for radius grinding. The rotating base of the cutter head has a 140-deg graduation. The cutter feed dial is graduated in 1/1000 in. and is powered by a 1/6-hp motor.—*New Hermes, Inc., 13–19 University Place, New York 3, N. Y.*

Permeameter

A high-H permeameter for magnetic testing. It is suitable for exact measurements of normal induction, hysteresis, and other characteristics of magnetic materials which require magnetizing forces up to more than 5000 oersteds. Features of the instrument include: small specimen size; direct-reading calibration system; remotely controlled flip-coil system for measuring H; double-H coil; and means for positioning of specimen in horizontal, vertical, and lateral directions. The apparatus consists chiefly of an electromagnet assembly with specimen-holding device and test-coil system, control box, power-operated reversing switch, galvanometer, and mutual inductor. —*Rubicon Co., Department E, Ridge Ave. at 35th St., Philadelphia 32, Pa.*

Dry-type Transformer

Hermetically sealed dry-type transformers with Class B insulation, available in ratings up through 1500 kva and 15,000 volts. They can be supplied with G-E metal-clad switchgear for load-center installations or with network protector and high-voltage switch as a completely equipped network unit. Tests show that Class B materials in a nitrogen atmosphere can be satisfactorily operated at 180 C previously assigned only to Class H materials. This considerably broadens the field of application of dry-type transformers. They can now be installed either outdoors where there is no exposure to lightning or indoors without the expense of fireproof vaults, etc. Even underground installation can be accomplished without excessive maintenance, a previous requirement.—*General Electric Co., Transformer and Allied Product Divisions, Schenectady 5, New York.*

Signal Generator

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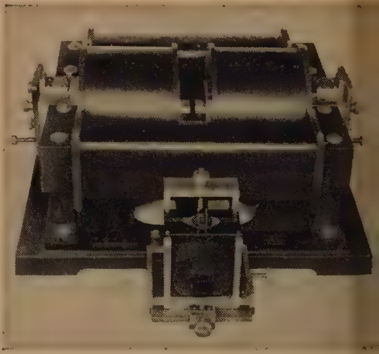
frequencies in 7 ranges, with double r
of 125 kc to 110 mc and 120 to 220 m
on fundamentals. Crystal accuracy
available to 0.005 percent for mobile b
of 30 to 50 mc and 152 to 162 mc. .
device provides accurately controlled m
lated and unmodulated output from 0.
100,000 microvolts through a 10 to 1 c
aluminum attenuator. Temperature c
pensation, negligible change in freque
due to output, and minimum leakage
factors contributing to the stability of
instrument.—*Hickok Electrical Instru
Co., 10577 Dupont Ave., Cleveland 8, Oh*

Signal Generator



Permeameter

Dry-type Transformer

igest

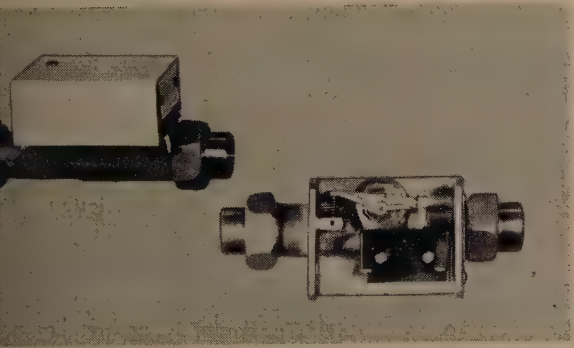
TIMELY HIGHLIGHTS ON G-E COMPONENTS

ace tubes BEFORE THEY FAIL! cord life with G-E time meters

m tube can usually be replaced *before* it fails if you have ate indication of operating time on the electronic device h the tube is used.

ime meters, with dependable Telechron* motor drive, perating time in hours, tenths of hours, or minutes, and plied for 115-, 230-, or 460-volts. The molded Textolite† monizes with other G-E 3½-inch instruments mounted ame panel. For more information, including dimensions, r Bulletin GEC-472.

. Telechron Inc. *†Reg. T. M. General Electric Co.*



sure protection against overheating!

E flow interlock opens the electric circuit of your water- components when water flow is lower than a preset n, closes it when flow is above this point.

nding on adjustment, the interlock will actuate the elec- act for any flow between ½ and four gallons per min- -in, cut-out differential is 0.1 gpm.

gs: 10 amps, 120 or 240 volts a-c; maximum water-line is 125 lb./sq. in. Unit is bronze with standard ½-inch s easy to install and adjust. See Bulletin GEC-411.

select 10 ranges INSTANTLY with this HIGH SENSITIVITY VTVM

CALIBRATED RANGES: .001 to 300 volts (10 cycles to 1.5 mc.); —52 to +52 db (ref. level —1 mw at 600 v.)

Just about everything you could ask for in a high-sensitivity vacuum tube voltmeter! Frequency range of this G-E Type AA-1 instrument is substantially flat from 10 cycles to one megacycle with voltage ranges of 0-.01, 0-.03, 0-0.1, 0-0.3, 0-1.0, 0-3.0, 0-10, 0-30, 0-100, 0-300, decibels from —52 to +52 in 10 ranges.

Ten-position pushbutton switch instantly selects range without passing through intermediate stages. This vacuum-tube voltmeter is stable, has high impedance input, uses full-wave rectification, and has an amplifier output of 3 volts. More in Bulletin GEC-461.

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☐ **GEA-4175 Welding control**
☐ **GEA-5338 Fan motors**
☐ **GEC-219A Fan motors**
☐ **GEC-411 Flow interlock**
☐ **GEC-461 Vacuum-tube voltmeter**
☐ **GEC-472 Time meters**

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TRADE LITERATURE

ACCELEROMETER—The ERA self-recording accelerometer is described with emphasis on its uses, making the record and playing it back, fields of application, and specifications. Four pages.—*Engineering Research Associates, Inc., 1902 West Minnehaha Ave., St. Paul W4, Minn.*

CONTOUR PROJECTOR—What the Model 2 contour projector is and how it can be used to magnify dimensions, shapes, and surfaces in production or tool making is the subject of a booklet describing both the features and application of the machine. Eight pages.—*Eastman Kodak Co., Industrial Optical Sales Div., Rochester 4, New York.*

COUPLINGS—Contains engineering information for the proper application of RC roller-chain flexible shaft couplings. Dimensions, weights, service factors, and horsepower ratings are included. Data are also given on two types of protective grease-retaining casings, Style R and Style P. Four pages. Folder No. 2363.—*Link-Belt Co., 307 N. Michigan Ave., Chicago 1, Illinois.*

ELECTROMAGNET—The ADL electromagnet is shown in different views and cross-section diagrams; the text lists its major features and research applications. Four pages.—*Arthur D. Little, Inc., Mechanical Div., 30 Memorial Drive, Cambridge 42, Mass.*

FORK TRUCK—Translates into user benefits the design and construction features of FT fork trucks in 3000- and 4000-lb capacity. Photographs show the trucks working in eight different industries and 16 applications. Eight pages. Bulletin 1324.—*Baker Industrial Truck Div., Baker-Taulang Co., Cleveland 2, Ohio.*

MOTOR-GENERATOR SETS—A publication covering motor-generator sets from 30 to 8000 kw as a source of d-c power for many industrial applications. Illustrations include typical installations and equipment undergoing test. Eight pages. GEA-5506.—*General Electric Co., Apparatus Dept., Schenectady 5, New York.*

RELAYS AND SWITCHES—Pleasing use of color in a well-designed plastic-bound manual containing pertinent data on numerous types of relays and stepping switches for industrial control. Typical applications, general features, specifications, etc. are given for each type of relay. Ninety-two pages. Catalog 4071-F.—*Automatic Electric Sales Corp., 1033 W. Van Buren St., Chicago 7, Ill.*

RELAY—An informative data sheet on power-type a-c voltage-sensitive relays, covering features, applications, principles of operation, characteristics, ratings, and dimensions. Two pages. Bulletin 401.—*Ward Leonard Electric Co., Mount Vernon, New York.*

STAINLESS STEEL—A headline "Six F
You Should Know About Armco Th
gage Stainless" introduces such topics
what it is, how supplied, and manufactur
advantages. A table of typical mechan
properties is given. Four pages. Tit
"Paper-thin Stainless for Light, Vital Part
—*Armco Steel Corp., Middletown, Ohio.*

TOOLS—A catalog with the informat
manual-type approach listing carboloy t
and parts, and also telling how to select a
apply them. Differences, and even limi
tions, in the various grades of carbide
clarified to facilitate proper selection. Fo
color illustrations add to its attractiven
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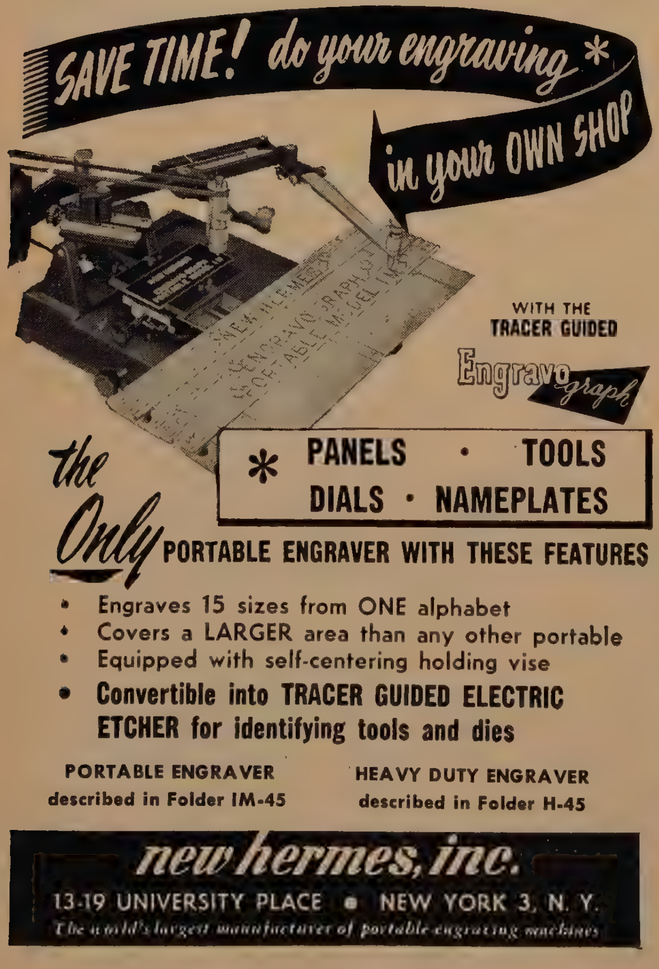
Sixty pages. Tool Catalog GT-250.—*C*
boloy Co., Detroit 22, Michigan.

TROLLEY COACHES—A booklet beginn
with the early development of trol
coaches continues on to summarize th
advantages, operation, and performan
Eight pages. GEA-5503.—*Apparatus*
partment, General Electric Company, Sc
nectady 5, New York.

WELDER—Presents the new PMCO 2
three-phase Modu Wave welder for resi
ance spot welding of aluminum, magnesiu
stainless steel, Inconel, Monel, brass, a
other alloys. Six pages. Bulletin 134-
—*Sciaky Bros., Inc., 4915 West 67th*
Chicago 38, Illinois.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BOOK REVIEWS

(Available books may be purchased through the GENERAL ELECTRIC REVIEW for domestic delivery; none sent on approval.)

HUMAN USE OF HUMAN BEINGS

rt Wiener—Houghton Mifflin Co.,
n. 1950. 241 pp. $3.00

s book comes from the heart as well as
nd of the author; one of the greatest
s of our day. What he says is always
sting, and also disturbing.

explains in simple terms the develop-
of automatic machines. The first of
repeated a series of motions without
e. Later, machines were devised with
ck mechanisms, that guided the
ns in accordance with the result pro-
, and stopped them when the sought-
sult was achieved. Now, the author
s of machines which are capable of
ng and will change their motions to
e a different and better result each
hat they operate, just as a child be-
more skillful after repeated trials.

author foresees a second industrial
tion, in which such automatons will
e factory labor except that requiring
l deal of judgment. From this theme,
elops his own philosophy of life and
ss, taking as the ideal to be sought the
of the French revolution—Liberté,
é, Fraternité—which he interprets to
"The liberty of each human being to
p in his freedom the full measure of
uman possibilities embodied in him;
uality by which what is just for A and
ains just when the positions of A and
interchanged; and a good will between
and man that knows no limits of
nity."

achieve these, he thinks it essential to
ain the freest possible communication
as throughout the world. And, he
s of dire misfortunes to come, if
t trends are not reversed. While the
does not contribute to peace of mind,
s impart the conviction that a lot of
can and should be done to make the
a better place in which to live.

P. L. ALGER

NCES IN COLLOID SCIENCE: Vol. III

l by H. Mark and E. J. W. Verwey—
cience Publishers, New York. 1950.
. $7.50

e is continued the pattern set by Vol-
I and II of this series, being a com-
n of essays on recent work in specific
of colloid science. The following topics
ated: Atomic Forces and Adsorption; Surface Chemistry and Colloids; Quantitative Interpretation of the Electrophoretic Velocity of Colloids; Lyogels; Ultracentrifugal Sedimentation of Polymolecular Substances; Fatigue Phenomena in High Polymers; Flotation. The book is of value more to the specialist than to the general reader. However, the first chapter by deBoer is a good discussion of the forces involved in adsorption. Dillon's extensive treatment of fatigue phenomena should be of interest to those concerned with the mechanical behavior of rubbers, fibers, and plastics.

W. E. CASS

CELLULOSE PLASTICS

D. N. Buttrey—Cleaver-Hume Press, London (U. S. distributor, Interscience, New York). 1947. 127 pp. $2.10

A very clear, concise description of cellulose plastics of all types. An excellent job of condensing and rationalizing many divergent theories and concepts in this field.

This book covers the occurrence and constitution of cellulose, cellulose nitrate, esters, and ethers.

Throughout the text the emphasis is on the theory behind the practical aspects of manufacture and use of cellulose plastics.

Recommended for persons interested in a general way in the structure of cellulose and cellulose plastics.

J. J. PYLE

ADVANCED PLANE GEOMETRY

C. Zwikker—North-Holland Publishing Co. Amsterdam (U. S. distributor, Interscience, New York). 1950. 307 pp. $6.00

This is a combination reference-text on analytic geometry. The author approaches the subject through the medium of functions of a complex variable, and defines everything in terms of the co-ordinates of the complex plane—an extremely logical and effective way of presenting the subject. The translation (or perhaps the author's English) could bear some improvement. However, in general, it is quite understandable.

The treatment of the subject is, for the most part, from the standpoint of the mathematician. However, the author does dwell considerably on physical aspects of geometry, developing in particular the circle diagrams of electric circuit analysis, orthogonal trajectories and the solution of Laplace's equation, conformal mapping, and the Schwartz transformation. There is also a chapter on the basis of gear-tooth profile selection.

In general, the book is an excellent reference in analytic geometry for the mathematician and for the analytical engineer.

J. C. WHITE

HIGH-SPEED COMPUTING DEVICES

Staff of Engineering Research Associates, Inc.—McGraw-Hill Book Co., New York. 1950. 451 pp. $6.50

This is a book that everyone directly concerned with the design or application of computing devices should not only read but have available as a reference book. It gathers together in one place information on the basic components of computing machines, a general survey of available computing equipment, and a discussion of methods. There is no logical arrangement of material, but this has an advantage in that the book can be opened almost at random and read with interest. The emphasis is on digital computers, the section on continuous-variable (called in the book "analog") computers being not nearly so complete. Finally, the book is devoted to factual information about computing devices, in pleasant contrast to some of the recent books in this field which have been more speculative and popular than informative.

C. CONCORDIA

STRUCTURE OF MOLECULES AND THE CHEMICAL BOND

Y. K. Syrkin and M. E. Dyatkina—Interscience Publishers, New York (Butterworths Scientific Publications, London). 1950. 509 pp. $8.75

This text attempts to treat comprehensively the theoretical and experimental aspects of the structure and properties of molecules. Some topics, such as the solution of the three electron problem using Slater's method, are treated in detail; others, such as the variation method, only superficially. The descriptive material is in general good. The translators, M. A. Partridge and D. O. Jordan of the University of Nottingham, have revised the sections on boron hydrides, spectra, molecular orbitals, and the hydrogen bond. Although based on

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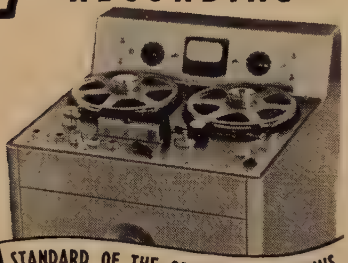

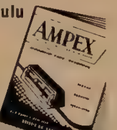

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BOOK REVIEWS

(Continued from preceding page)

the Russian edition of 1946, the choice of historical references reveals no nationalistic influence. Adequate references are listed at the end of each chapter; author, subject and formula indexes follow an extensive appendix of derivations. Recommended as a reference text.

Fred E. Williams

Technique of Organic Chemistry: Vol. III

Edited by Arnold Weissberger—Interscience Publishers, New York. 1950. vii+661 pp. $10.00.

The present volume in this series edited by Weissberger deals with what might be called the unit processes of organic chemistry. The subjects covered are Heating and Cooling, Mixing, Centrifuging, Extraction and Distribution, Dialysis and Electrodialysis, Crystallization, Filtration, and Evaporation and Drying. Each subject is covered by a section on theory followed by descriptions of apparatus available and examples of use of the equipment to do specific work. This book carries on the tradition of the series in being primarily a comprehensive laboratory manual. It should prove to be highly useful to chemists doing laboratory work.

J. R. Elliott

Analytical Absorption Spectroscopy

Edited by M. G. Mellon—John Wiley & Sons, New York. 1950. 618 pp. $9.00.

By far the most outstanding book in its field, comprehensive and understandably written, this book covers the problems of sample preparation, measurement methods, instrumentation, and data analysis in the ultraviolet, visible, and infrared spectral regions.

Specific contributions include a well-indexed discussion and table of chemical analysis methods for both organic and inorganic constituents and a chapter on spectrophotometer instrumentation, calibration, and standards. The most outstanding chapter is that on the application of spectrophotometric data, presenting a well-illustrated treatment of qualitative and quantitative analysis. With over 1000 references the book is not only a very practical laboratory guide but also an excellent reference manual for further investigations.

N. F. Barnes

Electrical Fundamentals, Circuits, and Machines for Engineers

R. W. Ahlquist—Pitman Publishing Corp., New York. 1950. 400 pp. $5.00.

This book is a very broad coverage of the present-day field of electrical engineering. Since it is of such a wide scope, it does not dwell upon any phase of electrical engineering to a detailed degree. The book was written to serve as a one-year text in electrical engineering for other engineering students. It can serve, however, as a handy refresher for any graduate engineer who does not need a detailed explanation of the phenomena it covers, or who can use his own knowledge to follow the paths indicated by the guideposts of the book.

R. L. Hamilton

Industrial Instrumentation

Donald P. Eckman—John Wiley & Sons, New York. 1950. 396 pp. $5.00.

This is an excellent reference book for the engineer or graduate student. It reviews the principles of measurement methods employed in industrial processing, with considerable emphasis on the method and
fundamental mathematics involved in m
urement.

It is not a catalogue of the instrum
available, but deals with principles
fundamentals. The book covers composi
analysis instruments and methods by u
emission and absorption spectroscopic
ysis, mass spectrographic analysis,
similar methods. It covers methods of
plying instrumentation to processes,
vacuum instrumentation, and disp
ment measurement.

Many schematic diagrams of opera
principles and installations are inclu
Working the problems at the end of
chapter will give the reader a basic un
standing of both the principles and
minology in use in this field.

T. R.

Wave Mechanics: Vol. I—Elemen
Theory.

J. Frenkel—Dover Publications, New Y
1950. 312 pp. $3.50.

In the first two chapters the author
cusses the corpuscular and wave theori
light and matter and the uncertainty
tions. Wave mechanics, as he states, "
sists in describing the behavior of a par
by means of probabilities derived from
determination of the associated waves.
the idea of probability provides the
necting link between the parallel idea
particles and waves." These probabil
are calculated by means of the Schrödi
wave equation, and the discussion in C
ters 3 and 4 deals with the solution of p
lems in atom mechanics by means of
Schrödinger technique. Later there
discussion of statistical mechanics,
special reference to the Einstein-Base
Fermi-Dirac distribution laws and
application of the latter to electron
metals. The problems of the hydrogen
and atom and chemical valence are
dealt with.

The volume can be highly recommen
as an excellent, not-too-difficult intro
tion to wave mechanics.

Saul Dush

Wave Mechanics: Vol. II—Advan
General Theory.

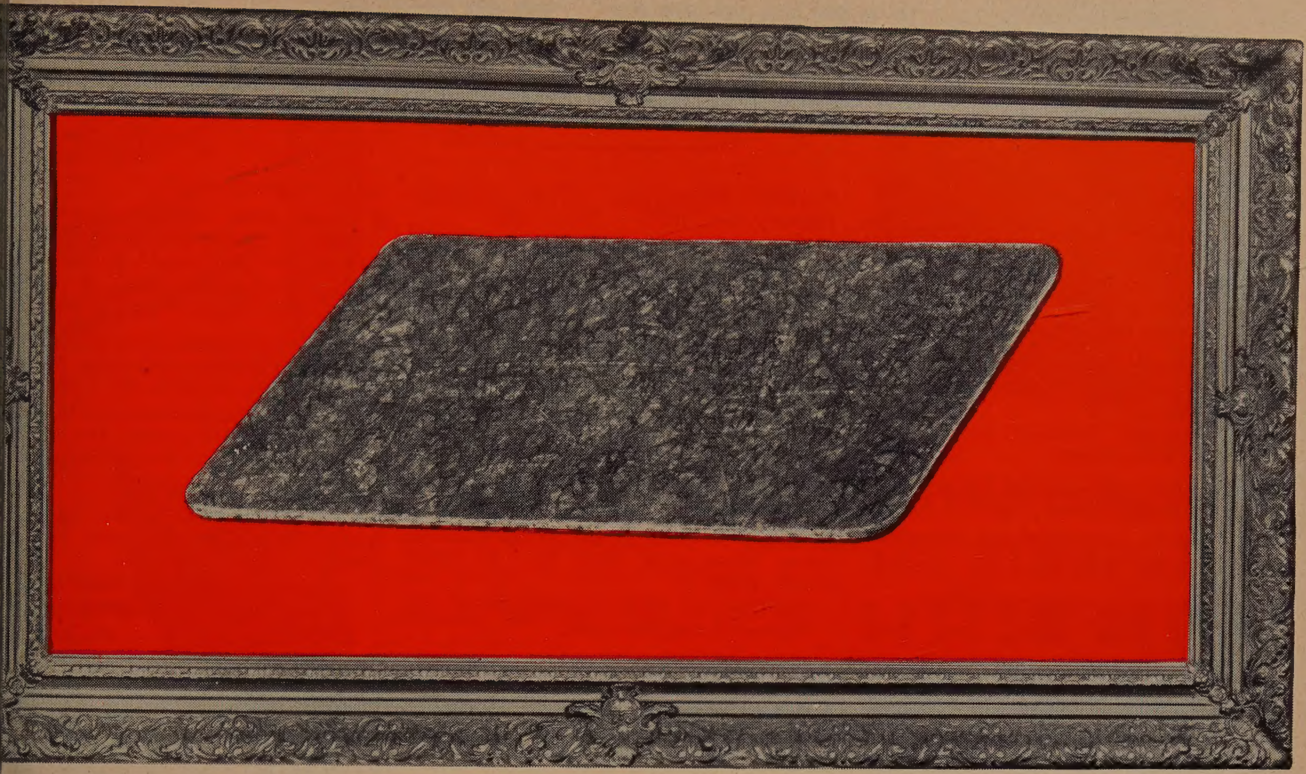
J. Frenkel—Dover Publications, New Y
1950. 525 pp. $5.00.

This is a companion volume to
on elementary theory. The main objec
this volume is the development of th
mathematical concepts which express m
adequately the physical principles of
new mechanics. After showing, in the
chapter, that the older, classical mecha
is essentially a limiting form of wave
chanics, the author discusses operat
matrices, and the transformation the
These considerations lead to a general
tion of wave mechanics along the line
Dirac's treatment.

Separate chapters deal with the pertu
tion theory and its application to transiti
between states; the relativistic refinem
of the general theory and electron s
and the problem of many particles and
exclusion principle. The last two chap
treat the problem of a system of ident
particles and the extension of wave
chanics to electrodynamics.

The book is obviously intended for
advanced student of the subject. It
not deal with the problems of nuclear for
but it should prove stimulating to the
perts interested in unifying the quan
phenomena with the deductions from
tromagnetic theory.

Saul Dush



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LIBRARY NOTES

ON ARTICLES IN OTHER TECHNICAL JOURNALS

AVIATION

Direct-current Control in Aircraft. J. D. Miner and B. O. Austin. *Aero Digest*, Dec. 1950; v. 61, p. 29.

A discussion of the 24-v d-c aircraft electrical system and its protection.

Ground Test for Omni Equipment. Scott H. Reiniger. *Aviation Week*, Dec. 4, 1950; v. 53, p. 33.

Describes test facilities for airborne omnirange equipment.

Jets Ablaze. Howard A. Klein. *Aero Digest*, Dec. 1950; v. 61, p. 30.

Discusses fire prevention and extinguishing in jet-engine planes.

CALCULATING INSTRUMENTS

Computers. *Chem. Engng.*, Dec. 1950; v. 57, p. 117.

A comprehensive discussion of high-speed computers from an engineering viewpoint.

Graph-scope, an Electronic Graph Plotter and Graphical Computer. A. L. Thomas, Jr. *Elec. Engng.*, Dec. 1950; v. 69, p. 1097.

Describes an electronic instrument which draws a graph with any number of coordinate lines.

CASTINGS

Effect of Oxygen Content on Iron Casting Properties. F. S. Kleeman. *Foundry*, Jan. 1951; v. 79, p. 100.

Causes of excessive amounts of iron oxide in gray iron and malleable iron castings and their influence on microstructure and other properties are described.

Engineering Properties of Iron Castings Can Be Improved by Heat Treatment. C. E. Herington. *Mat. & Methods*, Dec. 1950; v. 32, p. 50.

The uniformity of Meehanite iron castings, which makes them especially suitable for through-hardening as well as local or surface-hardening operations.

Interest in Continuous Steel Casting Gains Momentum. *Steel*, Dec. 25, 1950; v. 127, p. 68.

Describes the latest installations of continuous casting machines.

ELECTRETS

Apparatus for the Study of Electrets. Larry A. Freedman and Louis A. Rosenthal. *Rev. of Sci. Instr.*, Nov. 1950; v. 21, p. 896.

What About Electrets? How Soon Will They Be Workable Design Tools? Erik R. Nielsen. *Elec. Mfg.*, Dec. 1950; v. 46, p. 96.

An outline and discussion of research and development to date, plus an annotated bibliography of some forty selected papers.

MACHINE TOOLS

Carbide Burs Simplify Difficult
chining Operations. George H. DeG
Mach., Dec. 1950; v. 57, p. 155.

Describes various types of carbide
and their applications.

Hydraulic Duplicating Equipment
sures Repetitive Accuracy. *Prod. E*
& Man., Dec. 1950; v. 26, p. 69.

Describes the conversion of machine
to fast, semiautomatic, tracer-contr
operation by the use of hydraulic att
ments.

Optical Tooling Faster, More A
rate. George Elwers. *Iron Age*, De
1950; v. 166, p. 119.

Describes an optical method of align
of large aircraft assembly jigs and
tures.

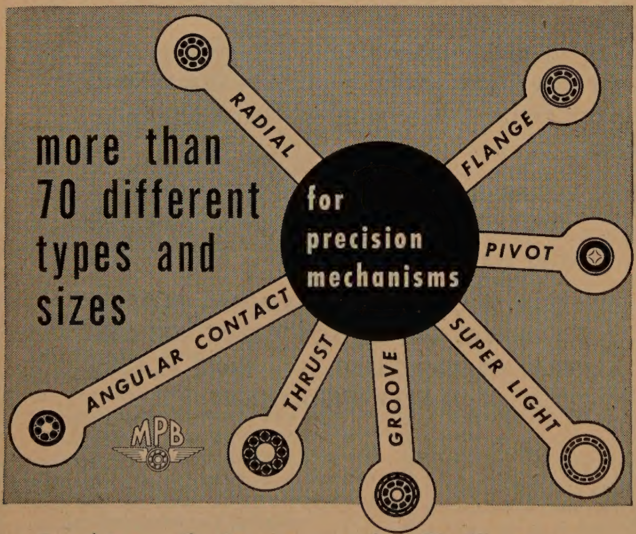
MEASURING INSTRUMENTS

Comparison of Geiger-counter and
chamber Methods of Measuring Ga
Radiation. W. K. Sinclair. *Nucleonics*,
1950; v. 7, p. 21.

The basic differences between these
systems of gamma measurement.

Notes on the Care and Use of E
trical Instruments. Frank D. We
Instruments, Dec. 1950; v. 23, p. 1236.

Presents notes on precautions that sh
be observed by users of electrical ins



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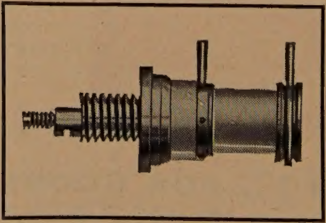

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Simple Manometer for Use in Measuring Low Air Velocities. D. B. Spalding. *Jour. Sci. Instr.*, Nov. 1950; v. 27, p. 310.

Two designs of a simple direct-reading instrument are described for measuring steady differential air pressure down to 0.002 mm. of water column.

METALS

How Furnace Moisture Causes Embrittlement. C. A. Zapffe. *Iron Age*, Dec. 28, 1950; v. 166, p. 60.

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New Production Applications of Hard Facing. E. C. Hurt. *Weld. Jour.*, Dec. 1950; v. 29, p. 1082.

How, with automatic and semiautomatic equipment, speed of production, uniformity, and quality are improved.

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RC Tuning Network Bandspreading and Scale Equalization. C. F. Van L. Weiland. *Television Engng.*, Aug. 1950; v. 1, p. 28.

Describes a system, evolved to provide partial equalization and completely equalized bandspreading, which simplifies scale reading from 15 to 15,000 cps without resetting of dial. Serial.

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A discussion of the relation between the sound-pressure curve of a loudspeaker and the transient response to a suddenly-applied unit sine wave, supported by photographs and oscillograms.

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How to Work Tool and Die Steel: Part 2. *Am. Mach.*, Dec. 11, 1950; v. 94, p. 147.

A classified list of 800 tool and die steels based on SAE and JIC methods, with names of suppliers, composition, typical properties, applications, and basic heat-treat data.

Super High-speed Steels Set New Production Record. P. Leckie-Ewing. *Iron Age*, Dec. 7, 1950; v. 166, p. 115.

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Device for Maintaining a Constant Potential for Electrochemical Work. F. W. Chambers and F. W. Berk. *Jour. Sci. Instr.*, Nov. 1950; v. 27, p. 292.

Describes an electrical system for controlling cathode potentials during electrolysis.

Static-magnetic Regulators in the Power Generation Field. W. A. Hunter. *Power Engng.*, Dec. 1950; v. 54, p. 66.

Tells what static-magnetic regulators are, and how they operate.

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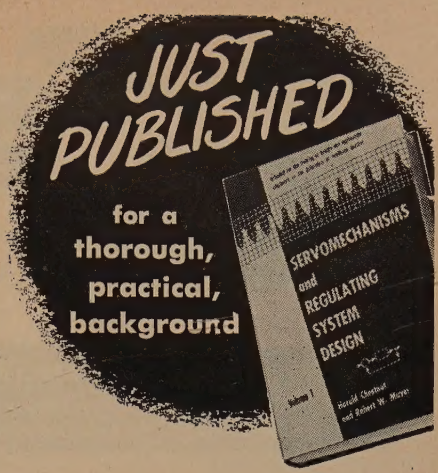
Designing a Large Weldment. L. G. Hauser. *Mach. Design*, Dec. 1950; v. 22, p. 168.

Describes the fabrication of a waterwheel-generator rotor by welding.

Welding High-temperature Piping. E. C. Bailey. *Weld. Engr.*, Dec. 1950; v. 35, p. 34.

Describes the welding of steam pipes which carry steam at 1800 psi and 1050 F.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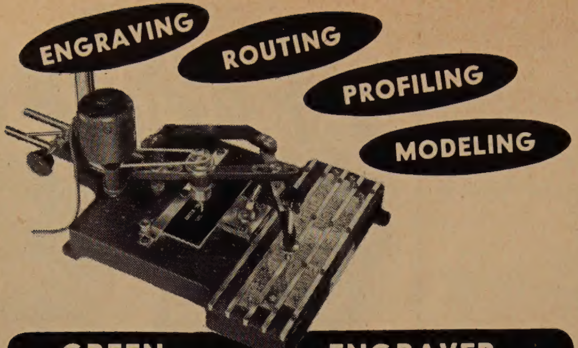

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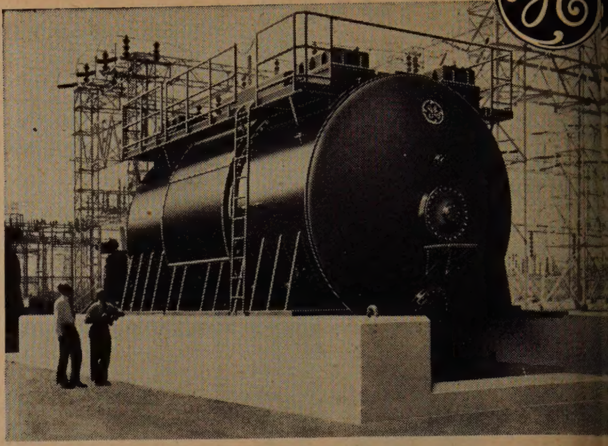

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